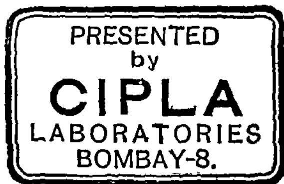
MODERN PRACTICE
IN
ANAESTHESIA

SECOND EDITION



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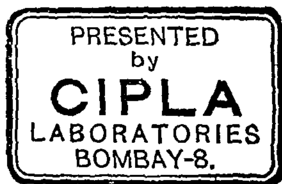
SECOND EDITION

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In humble dedication to those
Great Pioneers

HUMPHRY DAVY

JOHN SNOW   JOSEPH T. CLOVER

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INTRODUCTION TO THE SECOND EDITION

THE COMMENTS I made in the Introduction to the First Edition hold true today. The way of an Editor is still hard, but the difficulties encountered in a second edition are of a changed nature. Advances in anaesthesia, improvement in techniques and an ever-widening field tend inevitably to increase the size of the book, and this in turn tends to cause a rise in the cost of production. These factors unfortunately necessitate a restriction which is foreign to the nature of the poor Editor.

Chapters have been added, I think, with advantage, but unhappily the added chapters have meant the exclusion of one or two old friends. The few mistakes in the first edition which reviewers have so kindly pointed out have, I hope, been corrected, and I should like to take this opportunity of expressing my thanks and gratitude to all those contributors who have been so helpful in producing this edition and to all those who have lent blocks and illustrations. Once again I would also like to thank the publishing staff for their constant help.

FRANKIS T. EVANS.

INTRODUCTION TO THE FIRST EDITION

THE WAY of an Editor is hard. He has to try to steer a middle course, avoiding the rocks of over-enthusiasm on the one hand and the shallows of outworn methods on the other. To do this he needs a fair wind to enable him to sail full and by. Having decided who would be suitable contributors, the next task is to persuade them to write; and this is no easy matter. Some there are who give a very definite negative for answer; others agree to write and keep to the date required. Fortunately the latter are in the majority. There are a few, however, who agree to contribute, but at the eleventh hour fail to deliver a manuscript. Ultimately it transpires that for reasons beyond their control they will be quite unable to put pen to paper at all. This is one, and only one, of the problems that beset an editor. He can start all over again and try to persuade others to write the missing chapters, or he can sit down grimly and write them himself. I must admit that I chose the latter course, and if there seems too much of the Editor as contributor, gentle reader, make allowances for the lot of that harassed man.

So much has happened in the world of anaesthetics in the past few years, and so many discoveries have been made, that there must of necessity be divergent views in some quarters. There is the man who states that he never uses ether at all, and there is the anaesthetist who thinks that ether is still the best and safest of all anaesthetics. I feel that ether has served humanity well for over one hundred years; but I think the newer methods, the intravenous barbiturates and curare, will push ether into the background. The administration of ether and chloroform should

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and 129; S. & R. J. Everett & Co. Ltd., Fig. 83; Isolette, Fig. 162; *Guy's Hospital Reports*, Figs. 170-172; International Gas Detectors Ltd., Fig. 45; *Journal of Neurophysiology*, Fig. 66; A. Charles King Ltd., Figs. 29, 31, 33-35, 109, 111-113, 118, 158, 186, 199, 204, 206, 207 and 216 (*a*); *Lancet*, Figs. 63, 110 and 198; H. & K. Lewis & Co., Figs. 193-19
42, 43 and 213;
and 217; Medic
1-5; Oxford Medical Publications, Fig. 20; Oxygenaire, Fig. 160; Oxygen Therapy Equipment Ltd., Fig. 159; Photographic Department of the Medical College of St. Bartholomew's Hospital, Figs. 181-185; *Practitioner*, Fig. 211; *Proceedings of the Royal Society of Medicine*, Fig. 82; W. B. Saunders & Co. Ltd., Figs. 17, 84, 85 and 141.

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The Plate is reproduced by permission of the British Standards Institution; we also wish to make acknowledgement to the British Oxygen Company for use of this illustration.

still be taught, for there are occasions when their use is advisable; but "The old order changeth . . ." I have intentionally allowed differences of opinion and even contradictions to remain for these reasons, and leave it to the reader to make his choice I hope he seeks the middle way.

The modern anaesthetist must have a fair knowledge of anatomy and should be well versed in physiology For these reasons I have included chapters on these subjects as they affect the anaesthetist, and have added one on the chemistry of the common anaesthetics. As the anaesthetist of today is usually expected to take charge of saline infusions and blood transfusions, a chapter has been written on this subject by one who is a recognized authority, for fluid balance is an important subject Finally, a chapter has been added by a cardiologist of repute. In the past, young anaesthetists have been impressed by cardiac murmurs, and the thought of giving an anaesthetic to a patient with auricular fibrillation has given pause to many a resident anaesthetist. Now that catheters are passed into the very chambers of the heart with apparent impunity, we must be careful that we do not become swayed in the other direction Hence the chapter by the cardiologist himself.

All the contributors who have so kindly written chapters in this book are men of standing and practical ability in their subject, and I wish to thank them for their kindly help so willingly given, also I should like to express my thanks to Lord Horder, the Editor in Chief, for much kindly encouragement.

To the many who have lent blocks, and to others who have so courteously given permission for reproduction, our thanks are rendered. Lastly, my personal thanks to the staff of Butterworth & Co. (Publishers) Ltd., who have helped me in navigating what is to me an uncharted sea.

FRANKIS T. EVANS.

CHAPTER 1

HISTORY

ARCHIBALD D. MARSTON

HISTORICAL records reveal many interesting details of the constant endeavour of mankind to attain complete relief from operative pain, an ideal which was finally achieved just over 100 years ago by the introduction of anaesthesia.

The discovery of the phenomenon of anaesthesia was due to the efforts of many workers, and it is satisfactory to note that they were largely carried out by members of the Anglo-Saxon race living on both sides of the Atlantic.

INHALATION ANAESTHESIA

Nitrous oxide

The first definite contribution towards the discovery of anaesthesia was probably made by an English scientist named Joseph Priestley when he prepared and described nitrous oxide gas in 1777, for this anaesthetic agent was used in the first definitely witnessed general anaesthesia on 11 December 1844.

It is, indeed, remarkable that an interval of 67 years should elapse between the discovery and the clinical use of this gas, but it must be remembered that these events occurred at the dawn of the modern scientific era, and also that on several occasions success was very nearly attained.

In 1796 Humphry Davy, a young Cornishman aged 17 years, inhaled nitrous oxide and noted that it seemed to produce a definite effect on his mental processes.

At this time Humphry Davy was apprenticed to a surgeon in Penzance and hoped to qualify as a medical practitioner, but his interest in the great scientific advances of that period led him to adopt a purely scientific career. At the early age of 20 years, he became the superintendent of the famous Pneumatic Institute, set up in Clifton in 1799 by Thomas Beddoes with the financial aid of Wedgwood, the renowned potter.

In his new position Humphry Davy continued his experiments on the effects of the inhalation of nitrous oxide gas. On one occasion he inhaled this gas when suffering from the discomfort of an erupting wisdom tooth and noted that a definite relief from pain was effected by this inhalation; he also noted that the pain returned in due course after the inhalation was over. In 1800, Davy mentions in a publication, *Researches Chemical and Philosophical Chiefly concerning Nitrous Oxide*, the possibility of using this agent as a remedy for operative pain.

The writer ventures to suggest that medical history has recorded few examples more closely illustrating the aptness of the ancient adage "so near and yet so far". At this time Humphry Davy was pursuing fresh scientific researches with great vigour, and evidently lacked the time and inclination to pursue this matter any further.

popular lecture on "laughing gas" given by a Mr. Colton, described by Dudley Buxton (1900a) as "an itinerant lecturer in chemistry".

It seems that one of the audience was given an inhalation of nitrous oxide gas which caused him to become semi-conscious, and in this state he reeled about like a drunken man, and injured his leg by striking it against some obstruction. Horace Wells observed that this happening appeared to cause no pain to the individual concerned.

This train of events caused Wells to ponder over the possibility of using nitrous oxide for the painless extraction of teeth, and on the following day he persuaded Mr. Colton to administer nitrous oxide to himself, and Mr. Riggs, a dental colleague in Hartford, to extract one of his teeth.

According to Buxton (1900a) the experiment was a complete success, and Horace Wells announced vigorously as he returned to consciousness: ". . . a new era in tooth pulling. It did not hurt me as much as the prick of a pin. It is the greatest discovery ever made!"

After employing this method on several patients, Wells decided to give a clinical demonstration in Massachusetts General Hospital, and here the first of a calamitous series of misfortunes assailed him, for he failed to secure adequate anaesthesia, and was hooted from the theatre with shouts of mingled scorn and derision. Wells never recovered from this setback, and after much misadventure committed suicide whilst in prison. These events caused a temporary lack of interest in the use of nitrous oxide gas, and some 20 years elapsed before Colton reintroduced this valuable anaesthetic agent.

Ether

Diethyl ether was a drug of considerable antiquity, and according to Dudley Buxton (1900a) its original discovery is attributed to Djaber Yeber, an Arabian chemist; it was also described by Valerius Cordus, an assistant of Paracelsus, in 1540 and termed: *oleum vitrioli dulce.*

In 1758 Michael Morris had suggested the possibility of inhaling ether for therapeutic usage, and in the latter half of the eighteenth century there was an increasing tendency for physicians to prescribe ether inhalations for the treatment of certain pulmonary diseases. Many observers had noted the exhilaration, developing into a semi-inebriation, which consistently occurred during such inhalations, and in the early forties of the nineteenth century ether became a recognized alternative to nitrous oxide gas for the production of the "frolics", a name given to the strange parties in vogue at that time. It seems that such "frolics" became fashionable amongst medical students in England, and also in the United States of America.

In the autumn of 1841 Crawford Williamson Long, a recently qualified medical practitioner, gave a number of these parties at his house in Jefferson, Georgia, in the United States of America. Nitrous oxide was employed at first, but as it was difficult to get a regular supply, ether was used, and with equal success, for the participants secured their usual amusement.

Crawford Long noticed that he and his guests would sometimes suffer minor injuries, such as bruises and superficial abrasions of the skin, without any obvious immediate discomfort, and so he considered the possibility of using ether as an antidote to operative pain.

On 30 March 1842 Crawford Long put his ideas into effect, and administered

It is interesting to note that in the same year Henry Hill Hickman was born, and he did much to forward the possibility of attaining inhalation anaesthesia.

It seems that even as a schoolboy Hickman was appalled by the tragedy of unrelieved operative pain, and for this reason he decided to become a medical man. In due course he proceeded to Edinburgh, and as a student witnessed the sufferings of patients in the operating theatre, and decided that he would do his very best to devise some method of abolishing operative pain.

Hickman became a member of the Royal College of Surgeons of England in 1820, and commenced his career as a general medical practitioner in the town of Ludlow in Shropshire.

During the next four years he carried out a number of experiments on small animals, who were rendered free from operative pain by the inhalation of certain gases.

The exact nature of the gases inhaled is not definitely known, for although carbon dioxide was chiefly used, it has also been suggested by some historians that the nitrous oxide used by Humphry Davy was also exhibited (Macintosh and Bannister, 1943).

According to Hickman (1824) the animals were definitely rendered unconscious and free from pain by an inhalation technique, and this discovery was a further progress towards the goal of anaesthesia.

Unfortunately, this fact was not recognized at the time, for when Hickman read a paper before the London Medical Society in 1824, his views were received with apathy and considerable opposition.

For the next four years Hickman continued with his experiments, and in April 1828 he sent a petition to King Charles X of France requesting an opportunity to state his views and describe his research. In due course Hickman received an invitation to attend a meeting of the French Academy of Medicine which was held in Paris on 28 December 1828, and the matter was thoroughly discussed, but, alas, the French physicians were not impressed by Hickman's views and declined to pursue the matter any further.

These events were, indeed, a sad disappointment, and Hickman returned to his native land much depressed by his failure to secure interest in a quest which he was convinced would eventually meet with success. Henry Hill Hickman died on 5 April 1830, at the early age of 29 years. He was interred in the churchyard at Bromfield, and 100 years later his tomb was restored by the Section of Anaesthetists of the Royal Society of Medicine, and a tablet erected to his memory in the adjacent church.

On Wednesday, 30 October 1946, H.R.H. The Princess Royal unveiled a tablet erected in tl [illegible] thetists of C [illegible] of four Brit [illegible] generation [illegible] clearly indicated a path for posterity to follow.

Fourteen years elapsed before Horace Wells made his signal contribution to anaesthesia in the town of Hartford, Connecticut, in the United States of America, on 11 December 1844.

Horace Wells was a dental surgeon, and had always been interested in the various methods of alleviating the many discomforts associated with his own special branch of surgery, and it was indeed a fortunate chance which led him to attend a

popular lecture on "laughing gas" given by a Mr. Colton, described by Dudley Buxton (1900a) as "an itinerant lecturer in chemistry".

It seems that one of the audience was given an inhalation of nitrous oxide gas which caused him to become semi-conscious, and in this state he reeled about like a drunken man, and injured his leg by striking it against some obstruction. Horace Wells observed that this happening appeared to cause no pain to the individual concerned.

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On 30 March 1842 Crawford Long put his ideas into effect, and administered

ether by the open method upon a towel to a young man named James M. Venable. The anaesthesia produced was quite successful, and a cyst was removed from the occipito-cervical region.

Crawford Long operated upon the same patient for another cyst on 6 June of the same year, and subsequently on three other definitely recorded cases.

Although these ether anaesthetics were quite successful, they were not welcomed by the local population, and Crawford Long received no encouragement from the medical fraternity in the district. It is unfortunate that Crawford Long neglected to publish his work in any scientific journal or to read a paper before a medical society, and it was not until after Morton had independently introduced ether that Crawford Long published the details of his own work.

Nevertheless, credit must be given where credit is due, and Crawford Long deserves great praise for the courage and skill with which he carried into clinical practice the results of his original observations and ideas.

William Thomas Green Morton, another pioneer of anaesthesia, who was quite ignorant of the work of Crawford Long, proceeded to experiment with ether. Morton previously had been a partner of Horace Wells, and was an enthusiastic worker in the quest for freedom from operative pain. He had witnessed the unfortunate clinical demonstration at Boston, and after dissolving partnership with Wells, he proceeded to spend his time partly in dental practice and partly in attempting to secure a medical qualification.

In this endeavour he met Charles T. Jackson, a lecturer on chemistry and geology at Harvard University, and although this association had much to do with the successful clinical application of ether as an anaesthetic, it had the most dire effect upon the future life and prospects of Morton.

It seems that Morton, quite independently, had employed ether as a local surface anaesthetic on the skin, and had secured a certain degree of local analgesia from its use, and he had also conceived the possibility of using this drug as an inhalant for the production of narcosis. It is also true, however, that Morton sought the advice of Jackson on a number of occasions as to particulars of different preparations of ether, and also in regard to the construction of inhaling devices for their use.

Armed with this valuable information, Morton proceeded to try the effects of ether inhalation on two medical students, and as this experiment was not entirely successful, he decided to continue his research on small animals. Morton had a pet dog in his house which he repeatedly anaesthetized with success, and in September 1846 he succeeded in putting himself to sleep for eight minutes. At the end of the same month, Morton administered ether to a patient named Eben Frost for the extraction of a tooth, and this was a complete success, so much so that Morton asked permission to administer ether at the Massachusetts General Hospital.

The patient was a man named Gilbert Abbot, and after he had been anaesthetized with ether by Morton, a cervical tumour was successfully removed by John Collins Warren.

The operation was witnessed by a number of medical men, and Warren was sufficiently impressed by the completely successful anaesthesia to make his historic observation: "Gentlemen, this is no humbug".

After the Massachusetts demonstration Morton made an ill-advised attempt to conceal the nature of his anaesthetic agent, and endeavoured to patent it under the name of "Letheon", but this was opposed by Jackson, who now claimed all the credit for this great discovery.

In 1849 Morton presented a petition to the Senate of the United States for a gratuity as a reward for the discovery of anaesthesia, but this claim was vigorously contested by Jackson and the relatives of the late Horace Wells, and was never granted.

The details of Crawford Long's original administrations were then published for the first time (Young, 1897), and this was the only good result accruing from a long and bitter dissension as to the precise credit for priority in this great discovery.

The word anaesthesia was introduced by Oliver Wendell Holmes in 1846, and has persisted up to the present time.

Several historians have noted that this word was in existence for many years before its suggestion by Wendell Holmes to describe the phenomenon of unconscious freedom from pain, but in the writer's opinion this fact does not in any way detract from the credit due to this learned medical man.

Oliver Wendell Holmes was educated at Harvard University; he graduated in 1820, and in 1847 was appointed Parkman Professor of Anatomy, a post which he filled with distinction and held for no less than 35 years. Wendell Holmes is also famous as the writer of *The Autocrat of the Breakfast Table*, and was the author of many witty contributions to the contemporary literature of this period.

Introduction of anaesthesia in Great Britain

News of the Massachusetts demonstration soon spread over the world, and the first witnessed demonstration of anaesthesia in Europe took place in London some 9 weeks later. The fortunate chance which made this so speedily possible was due to the long-standing friendship between Bigelow of Boston and Boot of London, which occasioned the sending of a letter giving full details of Morton's successful ether administration.

Boot lived and practised in Gower Street, close to University College Hospital, and he proceeded to inform Liston of his interesting news.

On Monday, 21 December 1846, Liston operated on three surgical cases, and the ether was successfully administered by Squires, who used an apparatus specially modified for the occasion.

One of the operations was an amputation of the leg, and the spectators, who included several famous surgeons, were much impressed by the anaesthesia, and agreed with Liston's historic assertion: "This Yankee dodge beats mesmerism hollow."

It is not so generally known that two days previously, on Saturday, 19 December, a dental surgeon named Robinson administered ether to a Miss Lonsdale, and successfully extracted some teeth. This event took place at the house of Dr. Boot in Gower Street, and once again emphasizes the enterprise of the dental profession in the introduction of anaesthesia.

In Great Britain these events caused great interest, and in January 1847 articles were published in the *Lancet*, the *Illustrated London News*, and in *Punch*.

Chloroform

At this time James Young Simpson was Professor of Medicine in the University

of Edinburgh, and, as a leading exponent of obstetric practice, had always been interested in any endeavour which would mitigate the discomforts of childbirth He read about the administration of ether at University College Hospital, and at once proceeded to the metropolis to investigate the matter. Favourably impressed, he returned to Edinburgh, and on 19 January 1847 he administered ether to a woman in labour, and, according to John Snow (1847), "ascertained that it was capable of removing the sufferings of the patient without interfering with the process of parturition".

Simpson was a scientific and critical observer, and he noticed that ether, when administered by the somewhat crude apparatus available, did sometimes cause coughing, choking, struggling, shouting, and nausea or actual vomiting; consequently he decided to search for better results from an alternative drug.

He sought the advice of Waldie, who suggested the use of chloroform. Waldie was a fully qualified surgeon as well as a chemist, and became the Master of the Apothecaries' Hall of Liverpool; he knew of the experiments which had been made with "chloric ether", and his suggestion that its active principle, chloroform, should be used was an original and valuable item in the successful launching of this new anaesthetic agent.

Simpson was aided in his researches by two able and enthusiastic assistants, James Matthews Duncan and George Keith. On the evening of 4 November 1847 one of the most curious of the many curious happenings in the pioneer stage of anaesthesia occurred in the dining-room of Simpson's house in Edinburgh. It seems that Simpson invited his two assistants to join his family at dinner, and towards the end of the meal he produced a bottle of chloroform and proceeded to pour a little into several tumblers from which the company were invited to inhale.

Simpson soon lost consciousness and fell from his chair on to the floor, and the first sound he heard on waking was the stertorous breathing of Matthews Duncan, who lay unconscious beneath his chair. All the company were affected in various stages of anaesthesia, and Simpson, convinced of the ease with which the drug could be inhaled and the speed and efficiency of its action, decided to use chloroform in obstetric practice (Fulop-Miller, 1938). He used it with success in the next few days and soon gave an account of his conclusions before the Medico-Chirurgical Society of Edinburgh, and issued a pamphlet which excited great interest in the medical, ecclesiastical and lay press.

Strange though it may appear, the innovation of pain-relieved childbirth met with scanty approval from the majority of the British public, and downright opposition from a minority, amongst whom were numbered many representatives of the Established and Nonconformist Churches.

The basis of this religious objection was founded on the statement contained in the sixteenth verse of the third chapter of Genesis: ". . . in sorrow thou shalt bring forth children."

Not the least of Simpson's great contributions to anaesthesia was his resolute conversion of public opinion to a cordial recognition of this great gift to suffering mankind. He wrote a masterly pamphlet entitled *Answers to the Religious Objections Against the Employment of Anaesthetic Agents in Midwifery and Surgery*, and drew attention to the twenty-first verse of the second chapter of Genesis which reads: "And the Lord God caused a deep sleep to fall upon Adam, and he slept: and He took one of his ribs, and closed up the flesh instead thereof,". Commenting

upon this verse, Simpson in 1848 wrote: "In this remarkable verse the whole process of a surgical operation is briefly described. But the passage is principally striking as affording evidence of our Creator Himself using means of saving poor human nature from unnecessary endurance of physical pain."

In due course the clergy came to accept the fact that the deep sleep of Adam was a state akin to anaesthesia, and being realists they also observed the rapidly increasing use of this antidote to pain, and when in April 1853 Queen Victoria was graciously pleased to accept inhalations of chloroform at the birth of Prince Leopold, the last vestiges of opposition were swept away.

James Young Simpson was the first Scottish medical man to be created a Baronet, and he was also appointed a Physician-in-Ordinary to the Scottish Establishment of Queen Victoria.

Simpson died on 6 May 1870, and a memorial statue was erected to his memory in the St. Andrew's Chapel of Westminster Abbey.

The progress of inhalation anaesthesia

In 1846 John Snow lived and practised medicine in Soho, and was destined to carry out much valuable pioneer work in establishing this new special branch of medicine. In 1841 he had read a paper before the Westminster Medical Society entitled "On Asphyxia and Resuscitation of New-Born Children", which occasioned much interest (Richardson, 1858).

John Snow was 33 years of age in 1846, and all his work in and for anaesthesia was carried out in 12 years: he died at the early age of 45 years.

After witnessing several administrations of ether at University College Hospital, Snow decided that the existing method of administration was by no means ideal, and he proceeded to design an apparatus which produced much better results. Snow first used his apparatus at St. George's Hospital, and later was appointed to the staff of University College Hospital, where he had the privilege of administering anaesthetics for Liston, one of the most eminent surgeons of his time (Marston, 1942).

Before very long Snow became the first specialist in anaesthesia in Great Britain, and spent all his time in research work, writing books and scientific papers, and also carrying out an extensive private practice. In 1847 he published his first book, *On the Inhalation of Ether*, which had a cordial reception by medical men and had a large circulation.

The popularity of chloroform soon after its introduction caused a temporary abandonment of the use of ether, and, in common with other anaesthetists, John Snow proceeded to experiment with the new drug. He constructed a percentage inhaler in an endeavour to escape the effects of too strong a concentration of chloroform, which he suspected was the causative factor in the production of primary cardiac failure.

John Snow was the first research worker to carry out experiments with ether and chloroform on small animals, and his clearly written book *On Chloroform and Other Anaesthetics* (Snow, 1858) contains many interesting details of this research, carried out with great precision on mice, birds, guinea-pigs and frogs.

In 1853 Snow had the great distinction of being chosen to administer "chloroform *à la reine*" to Queen Victoria at the birth of Prince Leopold, and he was so

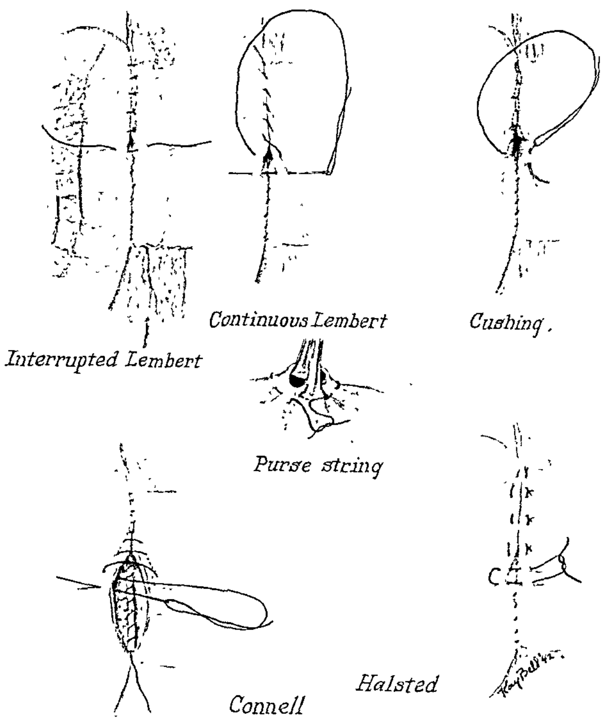


FIGURE 16. Types of intestinal sutures in common use.

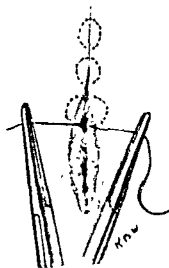


Fig. 17.

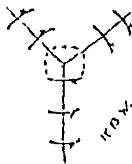


Fig. 18.

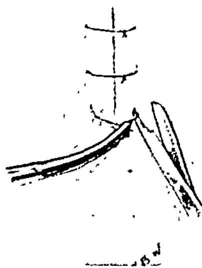


Fig. 19.

FIGURE 17. U-shaped horizontally placed interrupted sutures inserted at the base of the dermis for the careful approximation of skin edges. (Redrawn from Kazanjian and Converse: Surgical Treatment of Facial Injuries. Williams & Wilkins Company.)

FIGURE 18. Triangular wound closed without interference in blood supply of the angle. (Redrawn from Kazanjian and Converse: Surgical Treatment of Facial Injuries. Williams & Wilkins Company.)

FIGURE 19. Technique of removal of skin sutures. The suture is cut close to the skin to prevent pulling of unerusted or contaminated suture through the suture tract. (Kazanjian and Converse: Surgical Treatment of Facial Injuries. Williams & Wilkins Company.)

KNOTS

Knot tying is an important part of the technique of surgery. With experience, each operator will discover the method which he can use with greatest dexterity and efficiency.

The commonest knot used is the *reef* or *flat knot*. It is important to distinguish this from the "granny" knot, since the latter is much more likely to slip. The *surgeon's knot*, which consists in a double turn for the first tie, may be used to prevent slipping of the ligature. It is somewhat objectionable on the grounds that the second tie does not fit the first and the pressure exerted upon the tissues is difficult to estimate. To prevent slipping of the first tie of the reef knot, a hemostat clamped not too firmly on the tie will hold it in position until the second tie is run down. A knot is made more secure by a third tie drawn snugly against the second.

The skillful tying of knots with one hand saves time and ligature material. This also applies to tying knots with an instrument. The knots commonly used and methods of tying are shown in Figures 20, 21 and 22.

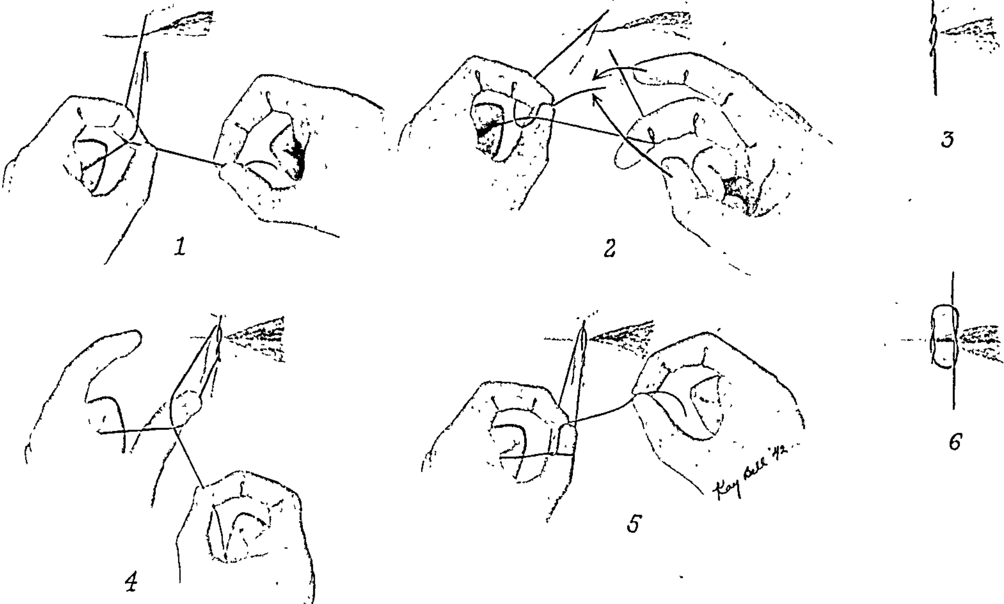


FIGURE 20 Knot tying with both hands.

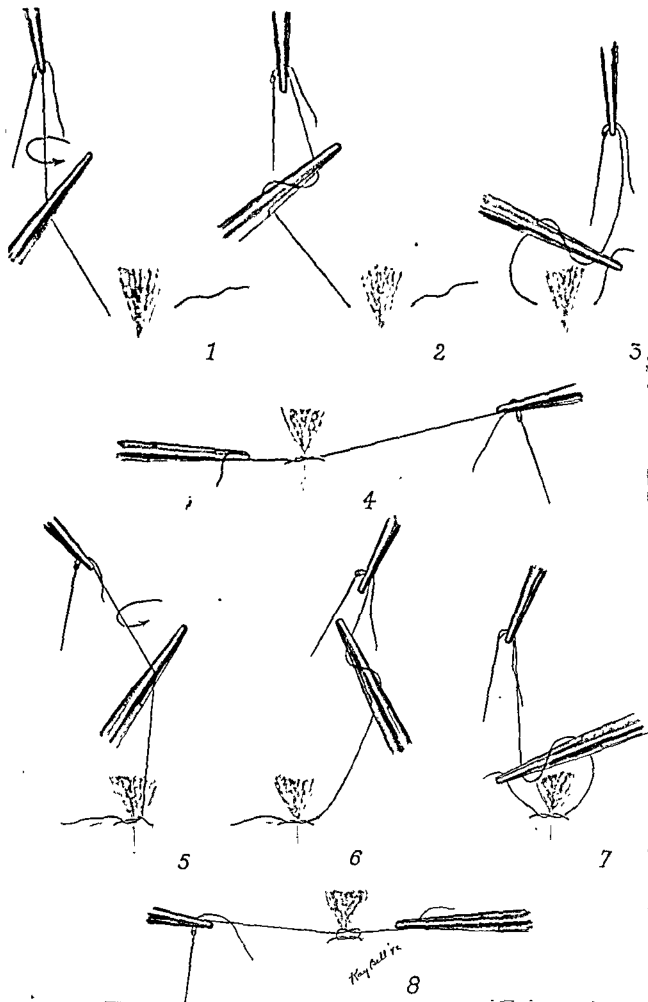


FIGURE 21. Grant's method of tying knot with forceps. The illustrations are self-explanatory.

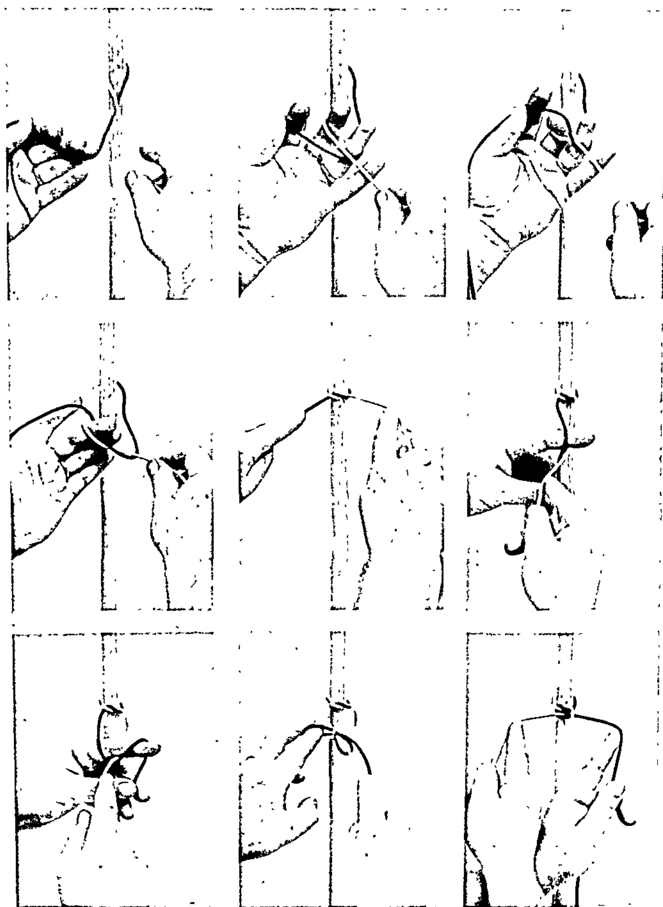


FIGURE 22 The one-hand method of tying sutures

CHAPTER 4

Amputations

General Principles

Indications for Amputation. The indications for amputations are disturbances of circulation, tumors, trauma, uncontrollable infection, deformity, uselessness of the extremity or any condition which may threaten the life of the patient.

Skin Flaps. It is essential that all skin flaps be selected according to available skin and blood supply. After injuries desirable flaps are often not available, and some discretion must be used in making the available tissue fit the part. Not infrequently, poorly shaped flaps, with resultant improperly placed scars, will give good functional results and are desirable to avoid sacrifice of bone. Irregularities

and puckering of flaps should be carefully avoided. This can usually be done by proper study of the tissue present and by applying the well known principles of plastic surgery. A well shaped flap usually makes a smooth stump when healed.

When possible, the deep fascia should be included in the skin flaps. This not only gives them stability, but also disturbs the blood supply less than lifting the skin alone.

In the feet and hands, plantar and palmar flaps should be used when possible. The skin of the sole or the palm is accustomed to weight bearing and pressure and will diminish the sensitiveness of the stump when used. It formerly was taught that in amputations of the leg and thigh, long anterior and short posterior flaps were usually desirable because, when the leg or thigh stump was thrust forward in walking, the anterior surface of the stump end came in contact with the artificial limb socket. At present, however, few if any prostheses made for the lower extremity allow any weight bearing on the end of the stump, all weight being borne on the sides of the stump. Therefore there is no real reason for not constructing both anterior and posterior flaps of equal length, as is commonly done in amputations of the upper extremity. It is a fundamental surgical principle that the placing of a scar upon a weight-bearing surface should be avoided.

Muscle. One requisite of a good stump is that the severed muscles receive a new insertion at the stump end. Redundant muscle tissue is useless and makes the stump more difficult to fit and prone to chafe. It is important that cut ends of muscles or their tendons be grouped about the end of the bone and fixed to the periosteum and fascia or to each other so that they will not retract and leave the bone exposed beneath the skin after healing.

Fascia. This is the strong tissue of the stump and should be used when possible to aid in muscle-grouping and to cover the end of the bone with one or two layers. Flaps of fascia may be used to advantage in some instances, as will be shown later. Fascia flaps sutured snugly over the end of the stump furnish a good tissue for muscle insertion.

Nerves. Proper care of the nerves is important to avoid painful stumps. After amputation it is usual for patients to complain that they can feel their toes or fingers and may for long periods of time complain of a "phantom limb." Neuromas developing on the severed nerve ends are common and should be avoided when possible at the time of operation by proper treatment of the ends of the cut nerves. In all cases the nerves should be drawn down from between the muscles and divided as high as possible. Herrman and Bollack recommend the placement of nonabsorbable ligatures tightly around the uninjured nerve trunk at least 1 inch above the amputation site. They believe that the ischemic necrosis at the end of the nerve thus produces fibrous tissue which completely encases the end of the nerve, thereby preventing the outgrowth of neuraxons and neuroma formation. Their preliminary studies indicate that injection of 5 per cent formaldehyde proximal to the ligature may be the most appropriate method of treating the large nerves encountered in amputations.

The painful amputation stump may present a problem which cannot be solved by any known method of treatment. Excision of a neuroma will relieve pain if it is definitely tender and if pain is relieved by a trial injection of procaine. "Incapacitating pain after amputation may be due either to irritation of end-bulb neuromas in the stump, or in the case of a phantom limb with persistence of pain and postural sensa-

tions, to their projection from the sensory areas of the cerebral cortex" (White). When the pain is confined to the stump, operations upon the regional sympathetic outflow may give relief. Chordotomy may be indicated in some cases. White says that these measures invariably fail after the personality has started to deteriorate from prolonged suffering, introspection and morphine addiction. This author offers the suggestion that operations upon the higher brain centers, from which the phantom sensations may be projected, may theoretically offer some hope of relief.

Blood Vessels. Careful hemostasis is always of prime importance. A tourniquet may or may not be used, depending upon the wishes of the operator. It is usually advisable except in those cases with advanced arterial disease in which a tight tourniquet might further damage the vessels. In certain types of amputation, such as disarticulation at the hip, preliminary ligation of the chief vessels should be done. When ligating vessels in the stump, as little tissue as possible should be included in the ligatures. Strangulated tissue predisposes to sloughing and infection. All bleeding points should be carefully ligated to prevent oozing beneath the flaps which might interfere with healing. Secondary hemorrhage in infected stumps may occur several days after operation and prove to be serious. This complication should be kept in mind and the nurses and assistants warned of the possibility.

Bone. Treatment of the bone varies to some extent, depending upon the location of the amputation. Most authors agree that the periosteum should be removed from the end of the divided bone for a distance of 0.5 to 1 cm. This is the *aperiosteal method* of Bunge. The removal is best done by first encircling the bone with a knife and then thoroughly scraping the periosteum away with an ordinary bone curet. The bone is divided below the clean-cut periosteal line. In patients of advanced age with impaired circulation, or when infection is probable, the aperiosteal method should not be used. In such cases the bone should be severed along the line of incised periosteum. Ring sequestra may form in the presence of infection or impaired circulation if the end of the bone is deprived of its periosteum. It is not good judgment to cover the end of an amputated bone with the periosteum, since this structure is very sensitive, and redundant periosteum is apt to result in bony outgrowths. All rough portions of the bone should be removed with the saw, file or rongeur. Bone bleeding may be controlled by sterile bone wax or, better, by instrument pressure.

Drainage. It is seldom necessary to drain a clean amputation. When drainage is advisable, small rubber tubes with perforations or rubber tissue may be used. If a stump becomes infected, a part or all of the stitches should be removed and good drainage instituted. By early and proper care of an infected stump, a reamputation can often be avoided. In connection with the diagnosis of infection, it is to be remembered that a hematoma under pressure beneath a flap may produce a fever and leukocytosis with no discernible infection

Instruments. The ordinary instruments used in other operations are used for the soft parts. A rongeur, bone curet, bone forceps, saw and perhaps a rasp file should be added to these. The long catlins and amputating knives, the elaborate tourniquets, Wyeth's pins and multiple saws are not desirable or necessary. They are relics of the day when extremities were removed in great haste without regard for future function of the stump.

Sutures and Ligatures. No. 000 chromic catgut is usually sufficiently strong to ligate most of the vessels. Somewhat larger chromic gut is advised for the larger

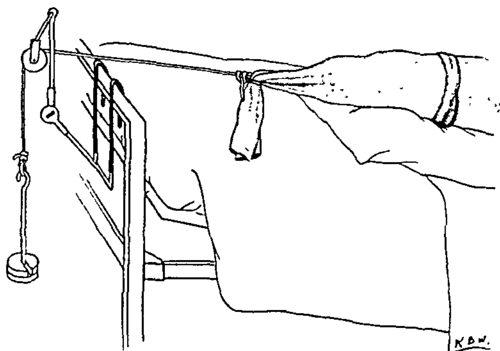


FIGURE 23. Stockinette traction to promote healing and preserve length of skin. (Redrawn from W. H. Cole: Operative Technic in General Surgery. Appleton-Century-Crofts.)

arteries, the fascial flaps, and for the grouping of muscles. Silk may be used in clean stumps, but nonabsorbable material should not be buried in the stump when infection is a probability or in the presence of impaired vascularity. Sinuses sometimes form from such foreign material and prolong healing and perhaps necessitate another operation. Silk or cotton is preferred in the skin and is usually placed as interrupted stitches. The "on-end mattress" suture is valuable to prevent turning in of skin edges.

Dressings. A snug dressing, not too thick, should be applied to the end of the stump in a manner to equalize the pressure as much as possible. Such a dressing will minimize oozing. In twelve to twenty-four hours the stump is likely to swell and the dressing become tight. This swelling produces considerable pain and may reduce the blood supply. It is a good plan to loosen or change the dressing within twenty-four hours. A circular or constricting dressing of any type is never applied to a stump when the amputation has been performed for peripheral vascular disease. Such a dressing may impair circulation and be deleterious to proper wound healing.

After returning the patient to bed the position of the stump is important. A stump held in flexion is usually most comfortable, but at the same time is most likely to produce flexion deformity, which will delay or interfere with proper artificial limb fitting. The application of gentle skin traction, using adherent stockinette for the first few postoperative days, will help prevent this rather crippling defect. This is a more effective and more comfortable method than the use of splints. Full range of motion of the nearest joint should be urged very early (Fig. 23).

Anesthesia The choice of anesthesia must be left to the surgeon's judgment. Local anesthesia for finger and toe amputations is usually preferable if there is no infection or disturbance of circulation. One of the gas anesthetics gives ample relaxation for the major amputations. Spinal anesthesia may be the choice in selected cases. Refrigeration anesthesia is being used with success in amputations for arteriosclerotic and diabetic gangrene when the patient is a poor surgical risk.

Dangers and Safeguards. The danger of an amputation is in direct proportion to the general condition of the patient. Shock is always a factor to be considered, particularly with amputations through the thigh, at the hip and at the shoulder. Blood transfusions should be available for major amputations, especially when the general physical condition of the patient is not good.

More remote dangers are sloughing of skin flaps, infection and secondary hemorrhage. As a result of a serious infection of a stump, particularly of the thigh and upper arm, secondary hemorrhage may occur in the second week. A tourniquet should be attached to the bed so that it may be immediately available in an emergency.

Reamputations and plastic repair are frequently necessary after infections, gangrene or provisional "guillotine" amputations. The greatest care is necessary in such operations to avoid infection in the new wound. A final amputation or repair should not be done as long as there is gross evidence of infection or brawny edema in the part. A few days devoted to the careful treatment of an old edematous amputation stump will often mean the difference between success and failure.

The incidence of adherent scars and tender stumps may be minimized by careful operative technique. Deep scars with puckering of the skin tend to produce chafing. Tender stumps are usually due to neuromas, tender scars, adherent scars, bone spurs or chronic osteomyelitis. Contractures at joints, resulting from faulty position during convalescence, may present an important problem in artificial limb fitting. When the surgeon is doing an amputation, he should treat the tissues as carefully as in any major operation. With a few exceptions, major amputations are now done so that artificial limbs may be worn.

THE "GUILLOTINE" AMPUTATION

This operation was used extensively in both World War I and World War II. The term "guillotine" amputation means a deliberate cross section of an extremity without any effort made to form flaps for closure. A modified type of "guillotine" amputation may be made by severing an extremity obliquely. This permits the later formation of a skin and fascia flap for closure. An amputation stump may also be left open for later secondary suture by forming flaps and packing them apart until the danger of infection has passed.

There is rarely any indication for a typical "guillotine" amputation. Dressings of such operations are painful, and secondary hemorrhage is common. The modified "guillotine" or open flap operation may be useful in selected cases.

After the open or "guillotine" types of amputation there is a great tendency for all tissues to retract and expose the end of the bone. This may be prevented to some extent, and length of bone conserved, by applying traction to the skin. Sloughing flaps may also be protected by this means (Fig. 23).

AMPUTATIONS OF THE UPPER EXTREMITY

HAND

General Considerations

Any amputation involving the hand should be considered in its minutest detail before any part is removed. In finger amputations all tissue possible should be saved

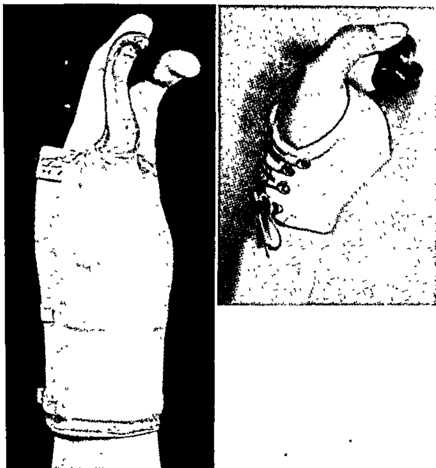


FIGURE 24. Work prostheses for partial hand amputations (Slocum. Atlas of Amputations, C. V. Mosby Company.)

that has any prospect of future function. The blood supply to the fingers is good; and it is, at times, surprising what tissues will remain viable. A finger may seem crushed beyond the possibility of recovery, but still heal and produce a part with function far superior to a short stump. One finger or thumb, if is has good motion, will be much more useful than a complete artificial hand. An apparatus can be fitted to enable the patient to grasp and pick up objects (Fig. 24).

Technique of Finger Amputation (Fig. 25)

Whenever possible in finger amputation, a long palmar flap is used. The palmar tissue is better adapted to pressure than the dorsal and will make firmer and less tender stumps. Great care is exercised in finger amputations to make the flap long enough and well fitting. Lateral digital arteries should be ligated with fine catgut or silk.

Careful section of the bone with bone-cutting forceps or a small saw will avoid bone splintering and delay in healing. The periosteum is carefully trimmed from the bone and removed for a millimeter or two from the bone end. If a disarticulation is done, the cartilage should be removed from the joint surface. Such treatment will reduce the sensitiveness of the stump. The tendons of the finger are sutured together over the bone end or attached to the periosteum.

Length of bone should not always be sacrificed to obtain perfect flaps. Sometimes what appears to be a rough piece of surgical work will produce a fairly good functional result. Drainage is usually not necessary unless infection is present.

Technique of Flap Closure for Traumatic Amputation of Finger

After traumatic amputation a flap or tag of skin is frequently found which is of sufficient size to cover the defect on the tip of the finger. Even though the blood supply to this flap may appear doubtful, it will usually remain viable and heal, provided the field has been well cleaned and is dry. Figures 26 and 27 illustrate the use of both lateral and volar flaps in closure of such injuries.

Plastic Operation for Finger Tip Amputation (Kutler) (Fig. 28)

The end of the severed finger is thoroughly cleansed, and all devitalized tissue is excised. A V-shaped incision is made on each side of the finger to form a triangular

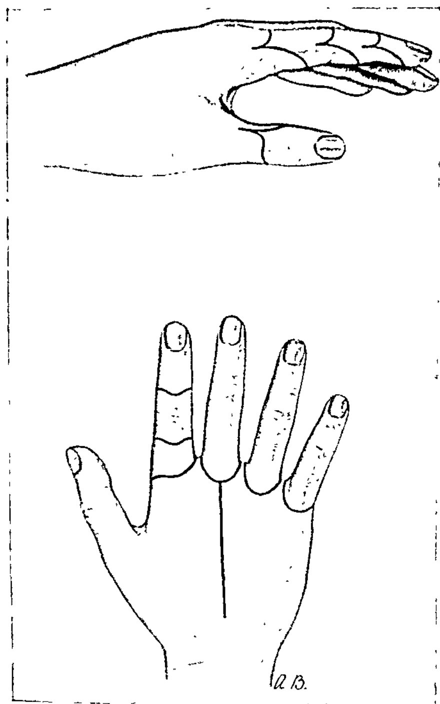


FIGURE 25. Skin incisions for finger amputations and excision of a metacarpal (Redrawn from Orr: Modern Methods of Amputation, C V Mosby Company.)

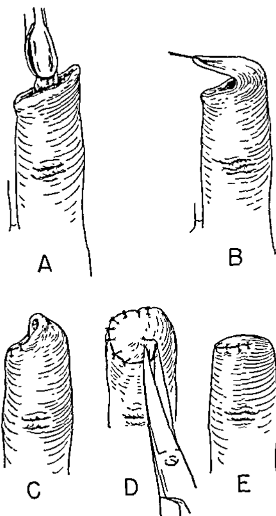


FIGURE 26. Stages in the technique of lateral flap closure of finger following traumatic amputation. (H. M Nichols: Manual of Hand Injuries. Year Book Publishers, Inc.)

skin flap. By extending the skin incisions into the subcutaneous tissues the triangular flaps will be loose enough to be approximated over the tip of the finger with fine silk or cotton sutures. The apices of the V-shaped defects in the sides of the finger are closed with sutures, and the flaps are sutured to the adjacent skin margins.

Full-Thickness Skin Graft for Traumatic Amputation of Finger (Fig. 29)

A traumatic amputation of a finger or an avulsion of a finger pad may be successfully treated with a full-thickness skin graft. A local anesthetic may be used for both finger and donor areas.

The finger about the wound is thoroughly cleansed with soap and water. If grease is present, it may be removed with ether. The wound surface is cleansed by gentle washing and irrigation with physiologic sodium chloride solution. Bleeding is controlled with gauze pressure. If the bone protrudes, it is cut down to the surface of the wound.

The donor site, which is usually the palmar surface of the forearm or the lateral aspect of the thigh, is prepared by thorough cleansing with soap or detergent and water. A full-thickness graft is cut slightly larger than the measured recipient defect. The graft is accurately sutured to the margins of the defect under slight tension. Any excess graft is cut away as the margin is sutured. Interrupted sutures of fine silk are used.

The graft is covered with petrolatum gauze, and a light pressure dressing is

applied. The dressing is changed on the fifth or sixth postoperative day, and the stitches are removed on the tenth day. The graft should be protected with a dressing for three or four weeks.

Technique of Metacarpal Excision

A metacarpal bone may be removed through an incision, as shown in Figure 25. The incision is made toward the wrist from the finger amputation incision to a point over the carpometacarpal joint. The bone is then excised and disarticulated with as little injury to surrounding structures as possible. Drainage is used if infection exists.

Technique of Amputation through Metacarpals

At times it may be necessary to amputate across the hand, leaving the thumb and perhaps one or more fingers (Fig. 30). In such cases a liberal palmar flap is used when possible. A palmar flap of skin and subcutaneous tissue will make an adequate covering for the bone ends. Bleeding is often abundant and should be controlled with fine ligatures. The flexor and extensor tendons are sutured together over the bone ends or to the bones to give them a proper insertion to aid future function. The bone ends are made smooth and freed from periosteal tags or shreds. Drainage is seldom necessary.

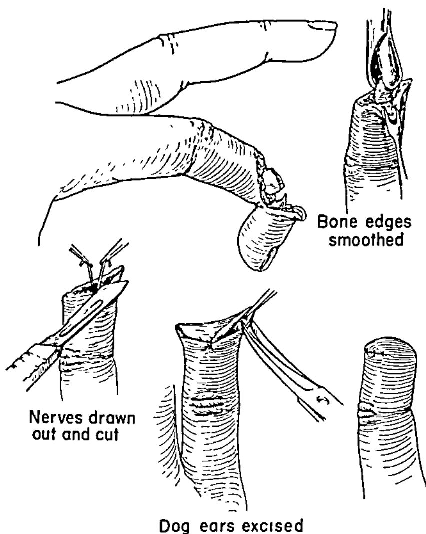


FIGURE 27. Volar flap closure following oblique traumatic digital amputation. (H. M. Nichols: Manual of Hand Injuries Year Book Publishers, Inc)

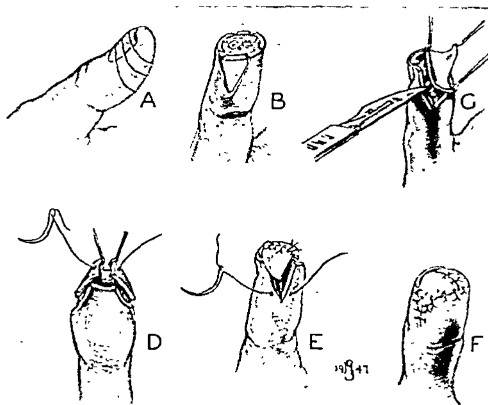


FIGURE 28 Steps in the plastic operation for finger tip amputation. (Redrawn from Kutler: J.A.M.A.)

Technique of Fillet of Finger (Fig. 31)

Removal of certain lesions on the hand may require wide excision of contiguous soft tissues. These are occasionally conveniently closed by utilizing the flap remaining from a fillet of a finger. Traumatic soft tissue defects occasionally may require closure in a comparable manner. Usually the procedure is done in such a manner as to utilize the palmar surface of the skin. Incision is made over the dorsum of the finger and the tendons and phalanges removed. Care is taken to preserve intact the digital blood supply as well as the digital nerves. The resultant flap is then folded back to cover the defect. Any redundant tissue in the flap may be excised to allow the flap to conform

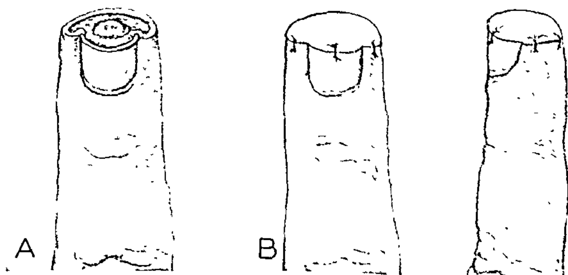


FIGURE 29 Technique of immediate full-thickness graft for a[illegible] finger tip. [illegible] finger ready for graft after removal of traumatized tissue. B Graft is [illegible] skin of def[illegible] (Redrawn from Reed and Harcourt Surg., Gynec. and Obst.[illegible])

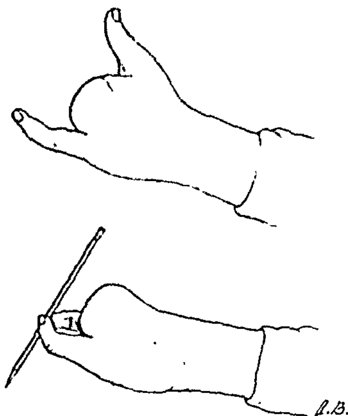


FIGURE 30. Amputation through the metacarpals showing value of preservation of thumb and fifth finger. (Redrawn from Wilson: Nelson's Loose-Leaf Surgery, Thomas Nelson & Sons.)

FIGURE 31 Fillet of finger to provide full-thickness skin coverage in repair of a large soft tissue defect.

to the wound in the hand. The skin is approximated with interrupted sutures of fine cotton or silk, and a gentle pressure dressing is applied. Excessive pressure should be avoided. Drainage is usually not required.

FOREARM

General Considerations

As a rule, an amputation through the wrist is undesirable (Fig. 32). It is difficult to fit an artificial hand, and when it is fitted, the apparatus projects beyond the length of the normal hand, producing an awkward appearance. However, retained carpal joints may have complete range of motion, and such a stump is useful for holding purposes. The site of choice in the forearm from the standpoint of limb fitting is at the junction of the lower and middle thirds. A site at any point above this junction to within 3 inches of the elbow will produce a good stump. Short forearm stumps are difficult to fit because the biceps muscle pushes off the limb socket when the elbow is flexed. An amputation should not be done through the elbow joint except for temporary purposes. A joint amputation produces a bulbous stump, which, if fitted with an artificial joint, makes a wide, unsightly arm and requires a laced socket above the bulbous end.

Technique of Forearm Amputation (Fig. 33)

A tourniquet may or may not be used, depending upon the choice of the operator. When possible, anterior and posterior flaps of equal length should be made. It is wise to outline the flaps on the skin before making the incision. The length of the flaps may be determined by measurement, making the sum of the two equal to one and one-half times the diameter of the arm (Fig. 43, p. 52). Include the deep fascia with the skin flaps. Cut across the muscles at least 3 cm. below the point selected for division of the bones.

Incise the periosteum by encircling both bones with a knife, and then use a sharp

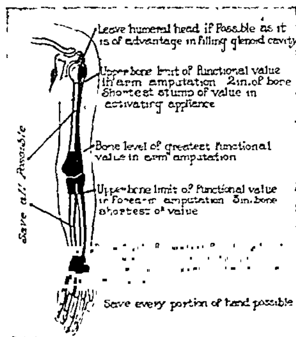


FIGURE 32. Locations of choice for amputations of the upper extremity. (Orr: Christopher's Textbook of Surgery.)

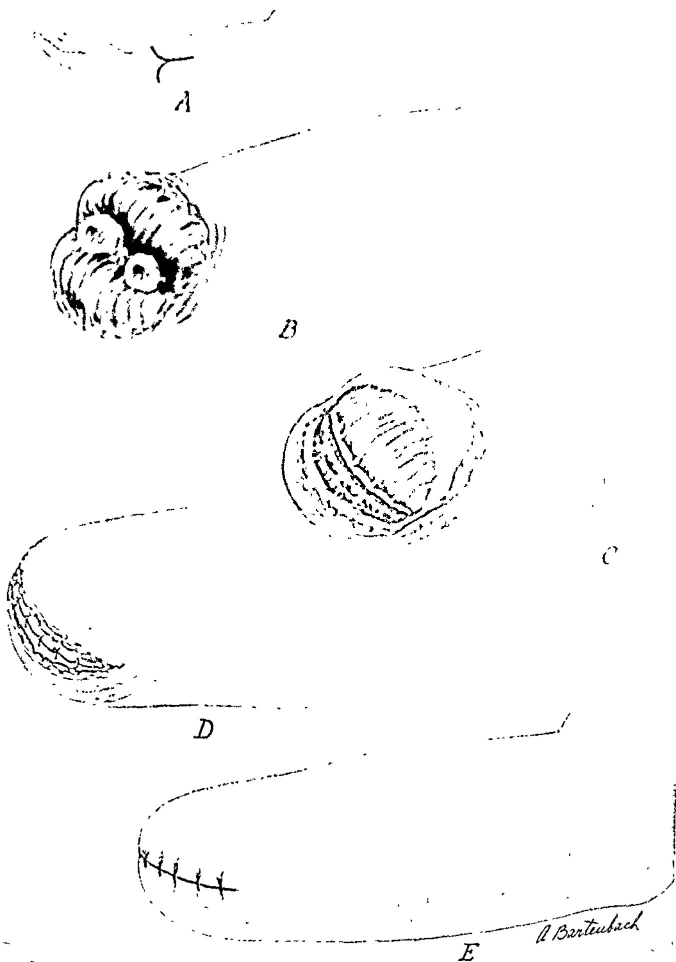


FIGURE 33. Amputation through the forearm. *A*, Anterior and posterior skin and fascia flaps of equal length. *B*, Muscle is reflected, showing bone ends denuded of periosteum. *C*, Muscles closed over the ends of the bones with mattress sutures. *D*, Deep fascia is closed over the muscles with interrupted sutures. *E*, Skin closed with interrupted sutures of silk or other nonabsorbable suture material (Redrawn from Orr: Modern Methods of Amputation, C. V. Mosby Company.)

bone curet to scrape the periosteum downward. The bones are divided through the denuded areas. Make the cut edges of the bone smooth with a rongeur or file.

Shorten the principal nerves by drawing them down and ligating them with a nonabsorbable suture material. The nerves may then be divided and the cut ends allowed to retract.

Carefully ligate all bleeding vessels with catgut. Suture muscles and tendons snugly over the ends of the bones with mattress sutures. To preserve pronation and supination, muscle or tendon should be placed between the bones near the severed ends.

Do not leave redundant flaps of muscle. Carefully close the deep fascia over the muscle in a separate layer, using chromic catgut. Close the skin with interrupted sutures of silk. Drainage is usually unnecessary. Apply a firm but not voluminous dressing.

ARM AND SHOULDER

General Considerations

The best arm amputation is immediately above the condyles. At any point above this to within 3 inches of the joint, limb fitting may be satisfactory (Fig. 32). When amputating higher than 3 inches from the shoulder joint, it is better to leave the head of the humerus in its socket to prevent a flattening of the shoulder, which may be apparent through the clothing.

Anterior and posterior flaps of equal length are preferable in arm as in forearm amputations. The pressure of an artificial arm is least upon the end and greatest upon the sides. Placing the scar on the end would then be the most desirable. The stump should be absolutely smooth with freely movable skin and fascia over the end. For an amputation through the surgical neck or disarticulation at the shoulder, the skin, fascia and muscle flaps should be lateral and of approximately equal length, placing the scar away from the point of the shoulder where it is not exposed to injury.

Technique of Arm Amputation

As in the forearm, anterior and posterior skin-fascia flaps of equal length are used (Fig. 34). Decide upon the point of section of bone, and cut the muscles 4 cm. longer than the bone. Treat the bone, nerves and blood vessels as in the forearm Group the muscles about the bone with purse-string or mattress sutures of chromic gut in a manner to prevent the bone from protruding and to give the muscles new insertions to bone and deep fascia, then carefully close the deep fascia over the muscles with interrupted chromic gut sutures. Close the skin with interrupted sutures of silk. If there is no infection and hemostasis is good, a drain is not necessary. Apply a light, snug dressing.

Technique of Tendoplastic Amputation of the Lower End of Humerus (Wilson) (Fig. 35)

The anterior and posterior flaps should be of equal length. The anterior flap extends downward below the elbow fold, and the posterior to a point about 2 cm. below the olecranon process. The biceps and triceps tendons are cut across and retracted with other tissues. The bone is exposed, denuded of periosteum and sectioned

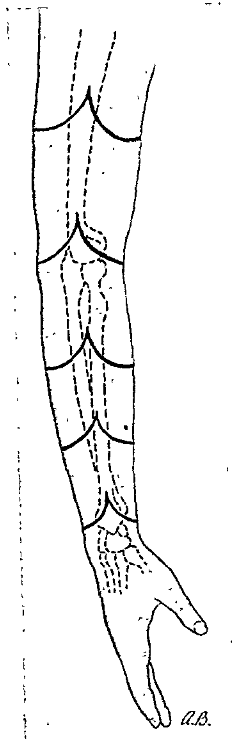


FIGURE 34. Lines of skin-fascia incisions for amputations through the arm and forearm.

just above the epicondyles. The supracondylar ridges are cut away with rongeurs, and the bone end is made smooth with a file. The nerves are divided high after ligation with silk or cotton.

The biceps and triceps tendons are sutured together with chromic catgut over the end of the bone. This closure makes a firm covering for the bone and prevents retraction of the muscles. The fascia is closed with fine chromic catgut and the skin with silk. Drainage is seldom necessary.

Technique of Amputation below Humeral Head, or Shoulder Disarticulation

Medial and lateral skin-fascia flaps are made of nearly equal length (Fig. 36). These flaps extend downward to the level of the deltoid muscle insertion. Divide care-

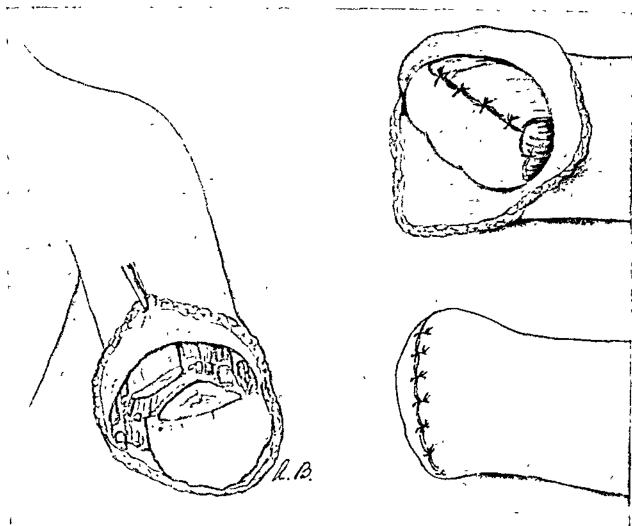


FIGURE 35. Tendoplastic amputation through the lower end of the humerus The humerus is sectioned just above the condyles. The tendons are preserved and sutured over the end of the bone. (Redrawn from Wilson: Nelson's Loose-Leaf Surgery, Thomas Nelson & Sons.)

fully the muscles and other tissues down to the bone. Do not use a tourniquet, but quickly clamp and ligate all vessels when cut. Divide the bone near the head, or disarticulate by cutting through the capsule.

Shorten all nerves up to the axillary space. Preserve the circumflex nerve so that innervation to the deltoid muscle may not be destroyed. As this nerve passes around the outer side of the surgical neck of the humerus, it may be avoided by dissecting close to the bone.

The muscles and fascias are carefully closed with fine chromic catgut, so that all dead space possible may be obliterated. A rubber tissue drain may be inserted to be removed in twenty-four hours. Suture the fascia and skin separately, and apply a snug dressing.

Technique of Interscapulothoracic Amputation

By this operation the arm, the scapula and a part or all of the clavicle are removed. There is usually considerable bleeding, and great care should be used in quickly clamping all vessels

Outline the incision as shown in Figure 37. Through an anterior incision section the clavicle with a Gigli saw near its inner end, or disarticulate at the sternum. The clavicular portion of the pectoralis major muscle is then divided from its origin. Exposure may be improved if necessary by severing this muscle from its insertion on

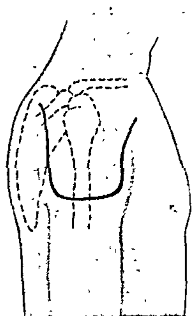


FIGURE 36. Lines of incision for disarticulation at the shoulder or amputation below the humeral head. (Redrawn from Orr: Modern Methods of Amputation, C. V. Mosby Company.)

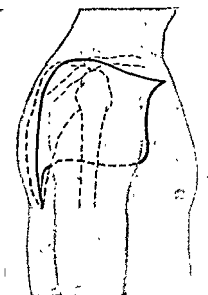


FIGURE 37. Lines of skin incisions for interscapulothoracic amputation by the Berger anterior method. (Redrawn from Orr. Modern Methods of Amputation, C V. Mosby Company)

the humerus. The axillary fascia is then incised, and the pectoralis minor muscle is cut at its insertion on the coracoid process. This exposes the axilla and its contents. The axillary vessels are doubly clamped and ligated with either silk or cotton ligatures. The brachial plexus is next divided, the proximal ends of the nerves being ligated close to the spine. The remaining muscular attachments of the shoulder girdle are then progressively divided and the entire extremity removed. Careful hemostasis is essential. The skin flaps are then closed, with provision for adequate drainage. A snug dressing is essential to minimize oozing beneath the flaps.

AMPUTATIONS OF THE LOWER EXTREMITY

FOOT AND ANKLE

General Considerations

For amputations of the lower extremity the two chief factors to be considered are locomotion and weight bearing. No amputation should be done without full consideration of these two functions of the amputation stump.

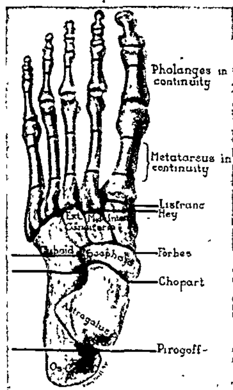


FIGURE 38 Skeletal lines of incision for several of the foot and ankle amputations. (Redrawn from Orr: Modern Methods of Amputation, C. V. Mosby Company.)

As a rule, it is unwise to leave a single toe. This applies to the great toe, as well as to the others. A single toe becomes painful and deformed and not only is useless, but also constitutes a disability greater than no toes.

An amputation through the metatarsus will produce a good stump. This is also true of the *Lisfranc* operation, which is a tarsometarsal disarticulation, provided care is used to retain the function of the flexor and extensor tendons of the foot so that deformity will not result from contractures by loss of muscle balance (Fig. 38). Any foot amputation proximal to the Lisfranc is of doubtful value and should not be done as a definitive amputation. The *Chopart,* which is a mediotarsal disarticulation, does not make a good stump because of the lack of muscle balance and consequent deformity due to contracture of the calf muscles, tilting the scar downward so that it becomes a weight-bearing surface. The *Pirogoff* amputation, which is a bone plastic operation designed to unite the posterior portion of the os calcis to the severed tibia and fibula just above the malleoli, is unsatisfactory because of the difficulty of obtaining solid bony union in a good position and because of the extreme difficulty of fitting with an artificial foot. The stump is too long for a good ankle joint. Subastragaloid disarticulation and other similar procedures have the same drawbacks as the Pirogoff. It is far better to jump from the Lisfranc to the Syme, leaving out the various operations in between as unsatisfactory from the standpoint of future function with artificial appliances.

The *Syme,* which is an amputation just above the malleoli, makes a good end-bearing stump, and is of sufficient length to enable a patient to go about his room without a crutch or artificial limb. The drawback to the Syme is the difficulty encountered in fitting without producing a wide, unsightly ankle. The advantages of a good Syme amputation are, as a rule, sufficient to offset the poor cosmetic results. The Syme is contraindicated in the presence of infection, in peripheral vascular disease and when nerve injuries cause extreme atrophy of the leg muscles.

Technique of Toe Amputation

Long plantar flaps are used in all cases when of sufficient length to make a closure without tension. Lateral flaps are satisfactory for metatarsophalangeal disarticulation. Because of the shape of the toes, it is sometimes difficult to outline the flaps so that they fit accurately. With care, much irregularity in the suture line is avoided and rapid healing promoted with smooth scar. Bone-cutting forceps are used to sever the bone. Other tissues are of little importance if a good pad of skin and subcutaneous fat forms the end of the stump. Drainage is not required unless infection exists.

Technique of Metatarsal Amputation

A long plantar and a short dorsal flap are planned (Fig. 39). The flaps are made of sufficient length to permit closure without tension. Everything is severed down to the bones, which are cut across with a saw. The periosteum is carefully removed from the bone ends for a distance of 2 mm. Tendons and muscles are sutured together or to the bone ends to promote smooth healing and prevent retraction.

The plantar pad of fat and fascia is sufficient to ensure a firm stump. As elsewhere, the flap is carefully shaped and smoothly sutured. Drainage is not necessary if there is no evidence of infection. A firm dressing is applied and changed in twenty-four hours.

Technique of the Lisfranc Amputation

The technique for this amputation is similar to that of the metatarsal (Fig. 39). The joints between the tarsals and metatarsals are disarticulated (Fig. 38). It is important to suture the chief tendons to the periosteum to strengthen the insertions of some and to give others new insertions. This is especially true of the tibialis anticus, tibialis posticus and the peronei tendons. Without such attachments there may result a muscle imbalance due to contracture of the posterior leg muscles which will impair the function of the stump.



FIGURE 39. Lines of incision for metatarsal or Lisfranc amputations (Redrawn from Orr: Modern Methods of Amputation, C. V. Mosby Company)

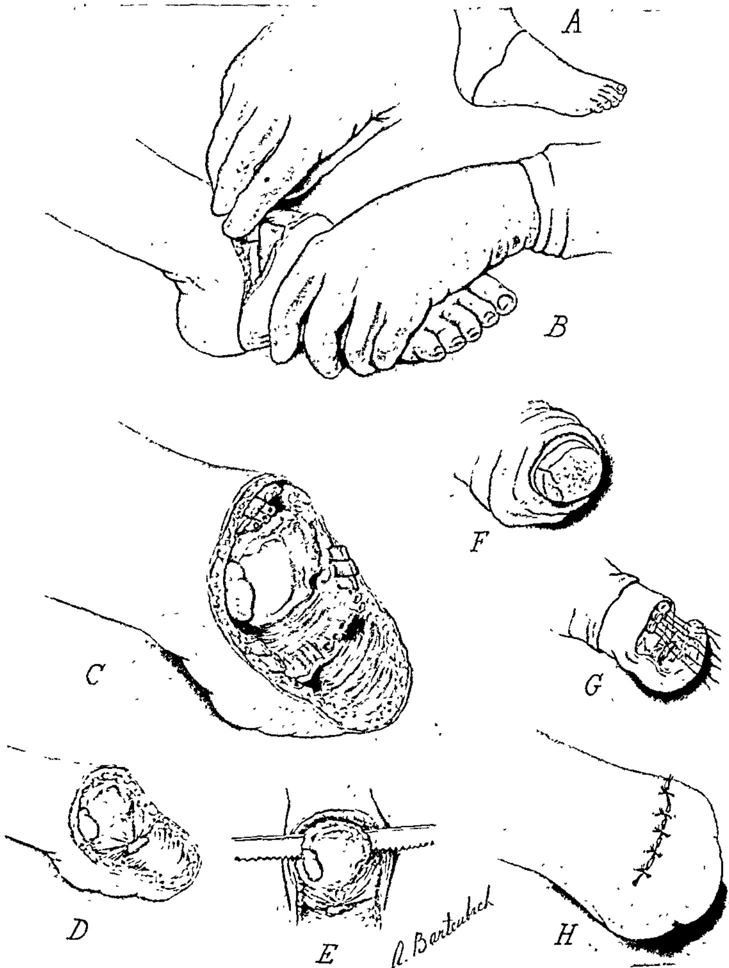


FIGURE 40. Steps in the Syme amputation. *A*, Skin incision. *B*, Separating astragalus from malleoli. *C*, Heel flap constructed, showing ends of tendons and blood vessels. D, Posterior tendons grouped together. *E*, Removal of articular surfaces of tibia and fibula with saw. *F*, Ends of bones denuded of periosteum. *G*, Sutures uniting anterior tendons to heel pad. *H*, Heel flap sutures. (Redrawn from Orr: Modern Methods of Amputation, C. V. Mosby Company.)

The plantar flap should be of sufficient length to cover well the end of the stump so that the pressure of an artificial form to fill out the shoe will not cause irritation. Careful closure of the skin makes a smooth scar.

Technique of the Syme Amputation

Skin incisions, as shown in Figure 40, are made down to the bone. The most care-demanding portion of the operation then follows. The heel flap is cautiously cut away from the calcaneus close to the bone without injuring the arteries on each side as they pass below the malleoli. The large and well defined posterior tibial artery passes on the medial side, and the terminal branches of the peroneal extend downward on the lateral side of the calcaneus. The success of the operation often depends upon the preservation of these vessels; whereas their destruction may result in sloughing of the flap and failure.

When the flap is entirely freed, it is retracted, and the malleoli are sawed through just above the articular surfaces. The periosteum is then removed from the ends of the bones for about 0.5 cm. The posterior tendons are sutured to the tendo achillis, and the anterior tendons are attached to the periosteum or to the heel flap in front, which is swung forward and sutured as smoothly as possible. There will invariably be some puckering which can be shaped to some extent after the suturing has begun. It may be wise later to do a slight plastic operation if too much redundancy of the flap remains. Care is necessary not to interfere with the blood supply when attempting to shape the flaps. Drainage is desirable. A snug dressing is applied to prevent the accumulation of blood and serum.

LEG

General Considerations

Above the location of the Syme, the best stump is made by amputating through the middle third of the leg, preferably 7 or 8 inches below the knee (Fig. 41). Amputation through the lower third is unsatisfactory because most of such stumps become

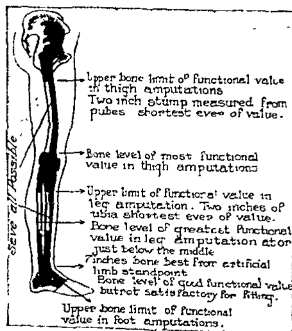


FIGURE 41. Locations of choice for amputations of the lower extremity. (Orr. Christopher's Textbook of Surgery)

atrophic, cyanotic and tender. A leg stump shorter than 3 inches cannot be satisfactorily fitted, and in such a case an amputation just above the knee will give greater function.

The old term "site of election" should be abandoned. It means an amputation about 4 inches below the knee, so that a kneeling stump may be used without the end of the stump projecting too far posteriorly for the convenient use of a peg leg.

Technique of Leg Amputation (Fig. 42)

In leg amputation it is usually advisable to use a tourniquet, which may be placed to advantage just above the knee. This must never be done, however, in the presence of peripheral vascular disease. Long anterior and short posterior flaps are made (Fig. 43). The deep fascia is included with the flaps. The skin and subcutaneous tissues are cut from the deep fascia downward from the posterior incision and a fascial flap freed which is somewhat longer than the diameter of the stump. To avoid sloughing, this posterior fascial flap should not be used in patients having poor circulation. The anterior skin flap with fascia is separated to the point of section of the bone or a little higher. The leg is then circled with the knife, and all tissue is cut to the bone about 5 cm. distal to the point of bone section. All tissues are separated from the bones and retracted to a height sufficient to section the bones with a saw (Fig. 44).

The bones are freed of periosteum with knife and curet at the site of section and sawed across, making the fibula 2 to 3 cm. shorter than the tibia. If the fibula is left as long as the tibia, it may become prominent, movable and tender, producing a stump difficult to fit comfortably. It is often wise, in short leg stumps, to remove the fibula entirely to produce a better tibial weight-bearing surface. The tibial crest is beveled with the saw for a distance of about 2 to 3 cm. to avoid its protrusion beneath the skin. The bone edges are made smooth with either a rongeur or coarse file.

The nerves are isolated, drawn downward out of the tissues as far as possible, ligated with cotton or silk and, after division, are allowed to retract into the proximal stump. All bleeding points are carefully ligated with catgut.

The muscles are grouped about the bone end with a purse-string suture of chromic catgut. If the bulk of the muscles is too great, a wedge-shaped section may be removed at the sides to avoid a bulbous stump. Additional mattress sutures may be added if necessary to group the muscles properly. The fascia of the posterior flap is then sutured over the end of the stump and to the muscle, carefully covering all muscle. The proper grouping of the muscles about the bones and careful covering with fascia afford an opportunity for a new and firm insertion for the cut ends of the muscles. Over this closure the anterior skin-fascia flap is placed and the fascia sutured to the posterior fascial layer. The skin is closed with interrupted sutures of silk. The cut edge of the anterior flap is always longer than the posterior, a fact which should be taken into consideration when closing the wound. By placing the sutures at a slightly greater distance apart in the anterior than in the posterior flap, it will be possible to avoid puckering at one end of the wound.

Drainage is seldom necessary. A firm dressing is applied which is usually removed in twenty-four hours to relieve pain produced by swelling and to prevent pressure which might reduce the blood supply.

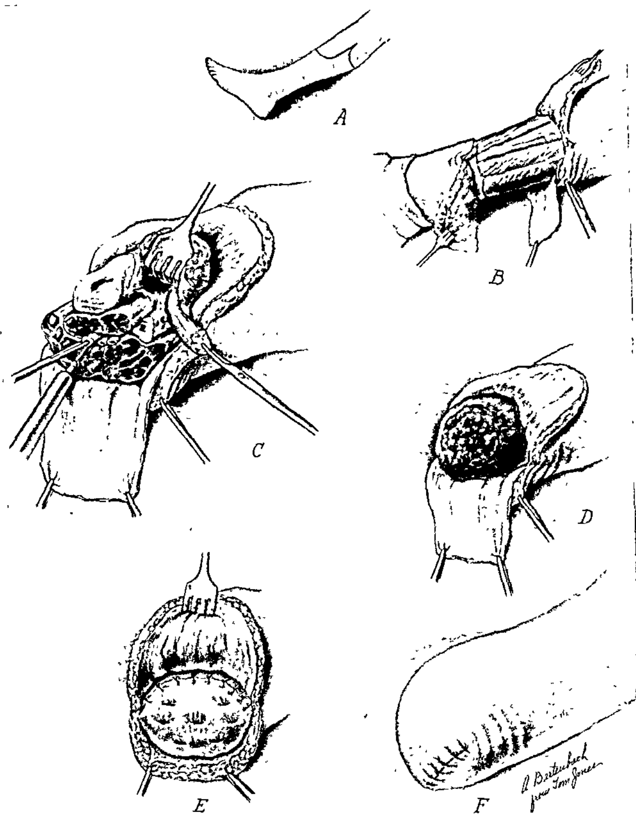


FIGURE 42. Technique of leg amputation. *A*, Lines of incision *B*, Anterior skin-fascia flap reflected. Posterior fascial flap has been separated from the posterior skin flap. *C*, Crest of tibia has been removed, and periosteum has been cut and scraped from the bone end. Fibula sectioned higher than tibia. *D*, Muscles grouped about ends of bones *E*, Posterior fascial flap sutured over muscles and bone ends. *F*, Skin flaps closed. (Redrawn from Orr: Modern Methods of Amputation, C. V. Mosby Company.)

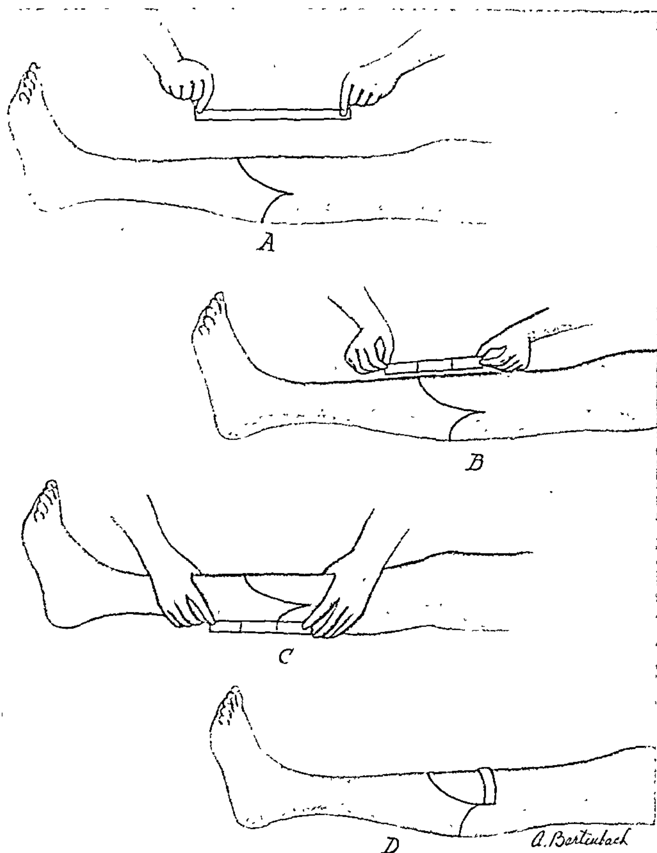


FIGURE 43. A method of estimating the combined length of the 2 skin-fascia flaps. The sum of the length of the 2 flaps should be at least one and one-half times the diameter of the extremity. One half of the circumference is approximately one and one-half times the diameter. *A*, Tape showing circumference. *B*, One half of circumference divided into thirds to measure the anterior flap twice as long as the posterior. *C*, Posterior flap measured one-half length of anterior. *D*, One half of the circumference of the extremity used to measure the width of the flaps at their bases. (Redrawn from Orr: Modern Methods of Amputation. C. V. Mosby Company.)

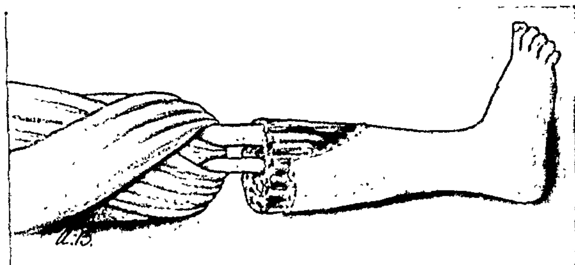


FIGURE 44. A 3-tailed cloth retractor which may be used in leg and forearm amputations. (Redrawn from Orr: Modern Methods of Amputations, C. V. Mosby Company.)

Maes Technique of Leg Amputation (Fig. 45)

In 1930 Urban Maes described a technique of leg amputation which he considered superior for selected cases of diabetic gangrene. It was designed to permit successful below-knee amputations in a greater percentage of cases by minimizing trauma and conserving a deficient blood supply. It is now known that this technique

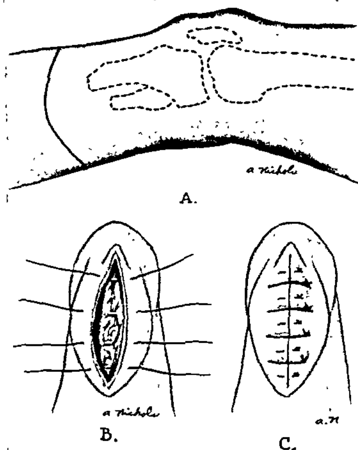


FIGURE 45. Modification of an amputation technique described by Urban Maes for peripheral vascular disease. *A*, Lines of incision; *B*, closure of wires; *C*, closed wound.

can be used successfully in other types of peripheral vascular disease, particularly those due to arteriosclerosis and thromboangiitis obliterans.

A circular incision is made around the leg at least 5 cm. below the site selected for section of the tibia, and the skin is allowed to retract upward. A second circular incision is made through the fascia at the retracted skin margin. The muscles are then divided to the bones at the margin of the retracted fascia. At the upper limits of the retracted muscle the tibia is sectioned. The muscles lateral to the fibula are incised to permit section of fibula 2 to 3 cm. above the end of the tibia.

The distal crest of the tibia is removed, and the margins of the severed bone are smoothed with a rasp. The periosteum is treated as in other leg amputations. The final appearance of this method of sectioning the skin, fascia and muscle is that of a cone with its apex at the severed end of the tibia. All bleeding vessels are ligated with fine chromic catgut. The nerves are treated as in other leg amputations.

The wound is closed in an anteroposterior direction with through-and-through sutures of heavy silk or steel wire which pass through skin, fascia and muscle (Fig. 45, *B*). The sutures are designed to obliterate dead space. Buried sutures are not used. Between the deep sutures, which usually are four to six in number, the skin edges are approximated with vertical mattress sutures of fine silk. A drain is not advised. A light gauze dressing is applied in conjunction with stockinette skin traction.

As a safeguard against necrosis, tight sutures should be avoided. Lateral wound margins should be long enough to close without tension. The dressing should be loosened or removed in twenty-four hours for inspection of the stump and to avoid constriction by swelling. The skin sutures should be removed in seven days and the through-and-through sutures in eight or nine days. Active movements of the knee should be started as soon as traction is discontinued, to prevent flexion contraction. The patient should be warned that contractures at the knee will prevent satisfactory fitting of an artificial limb.

THIGH

General Considerations

A thigh stump should be made as long as possible, but disarticulation should not be made through the knee joint because of the resulting bulbous stump which is difficult to fit. A knee-joint disarticulation has no advantage over the Gritti-Stokes or supracondylar amputation.

The Gritti-Stokes, which is an osteoplastic amputation at the knee, when properly done, is useful and makes a good end-bearing stump. It requires considerable care in operation and after-treatment to obtain the best results. The Callander amputation will also produce a sound end-bearing stump.

A thigh stump shorter than 2 inches, measured from the perineum, has no more value from the standpoint of fitting than a hip-joint disarticulation. It can be fitted, as can the latter, with a special type of limb having a firm pelvic girdle. These amputations are always undesirable and should be avoided whenever possible. The locations of choice for amputations through the lower extremity are shown in Figure 41.

Indications for the interinnomino-abdominal amputation are few. It has been done most commonly for some types of sarcoma involving the ilium or upper femur.

Technique of the Gritti-Stokes Amputation (Fig. 46)

Long anterior and short posterior flaps are made. Special care is advised in making the flaps so that they will fit accurately. The incision for the anterior flap is made across the tubercle of the tibia. The patellar tendon is severed at its insertion and

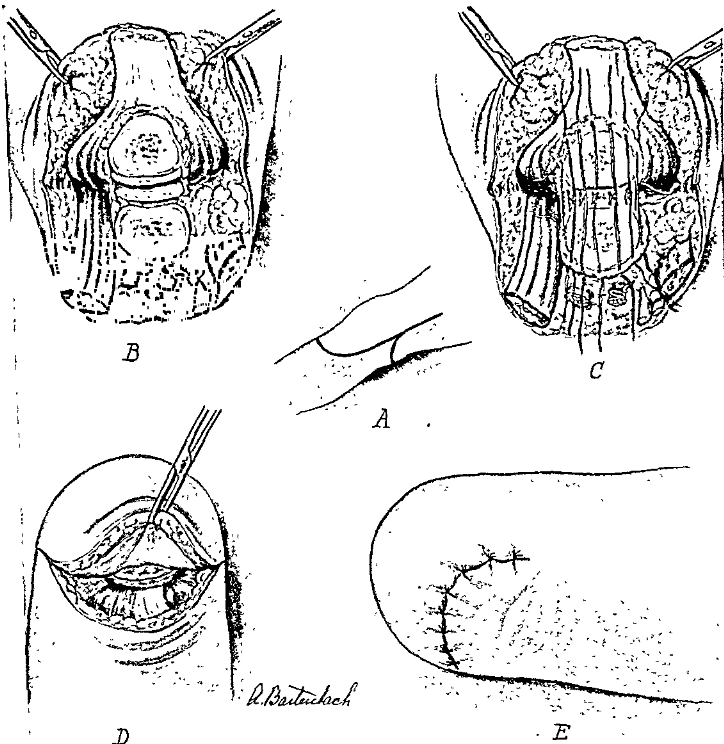


FIGURE 46 Steps in the Gritti-Stokes amputation technique *A*, Lines of the skin incisions. *B*, Appearance after femur has been sectioned and the articular portion of the patella removed. This sketch also shows the divided quadriceps extensor tendon and the ends of sectioned muscles, tendons, nerves and vessels. *C*, Sutures placed to fix patella to cut end of femur. *D*, Hamstring muscles and tendons sutured to patellar tendon *E*, Appearance of stump after closure of skin flaps (Redrawn from Orr: Modern Methods of Amputation, C. V. Mosby Company.)

preserved for future use. The joint is opened, and the patella is raised with the anterior flap.

The hamstring muscles are cut at their insertions. With an ordinary bone saw the articular portion of the patella is cut away. After denuding a circular area of periosteum, the femur is divided just above the condyles at a point where the cut end of the bone approximates the size of the cut surface of the patella. All synovial membrane is removed. Just above the patella, the tendon of the quadriceps extensor is divided to prevent the strong pull of that muscle tilting the bone during healing. By the time the patella is united to the femur, the severed tendon will have healed.

The nerves are pulled down, ligated with cotton or silk, divided and allowed to retract. Hemostasis receives careful attention. Excess fat and muscle tissue are removed. The patella is sutured snugly down on the cut end of the femur with interrupted chromic gut sutures through the fascia surrounding each bone. The gracilis, sartorius, semitendinosus and semimembranosus, with the biceps on the opposite side, are made the proper length to suture snugly to the patellar tendon. The suture of these muscles and tendons gives them a new insertion and balances the pull of the quadriceps extensor.

The deep fascia and skin are closed in separate layers. Interrupted sutures of silk or other nonabsorbable material are used in the skin. A drain is seldom necessary. The stump is dressed at the end of twenty-four hours.

As soon as the wound is healed and the stitches removed, it is wise to run a wide strip of adhesive across the end of the stump in two directions to make firm pressure over the patella. In addition to the adhesive, a plaster-of-paris cap may be applied to protect the stump end until the patella has united. After six or eight weeks a temporary limb is fitted and light end-bearing begun.

At present the Gritti-Stokes amputation is rarely done, since the vast majority of prostheses are no longer end-bearing in type. It is considered primarily for its historical interest.

Technique of the Callander Amputation (Fig. 47)

The knee is held slightly flexed. A tourniquet is not used. The incision is started on the medial aspect of the thigh at a point three fingerbreadths proximal to the most prominent part of the medial femoral condyle and is extended distally in the palpable groove between the vastus medialis and the sartorius muscles, over the medial epicondyle, and crosses the anterior surface of the tibia at the point of insertion of the patellar tendon. A similar incision is made on the lateral aspect of the thigh and leg over the groove between the tendon of the tensor fasciae latae and biceps femoris muscle.

Incisions are made from each femoral epicondyle over the posterior surface of the leg to a point distal to the anterior skin incision. Both anterior and posterior incisions are extended through the deep fascia, outlining anterior and posterior skin-fascia flaps.

On the medial side the incision is extended through the deep fascia, and the four medial hamstring tendons are severed at their insertions. The adductor magnus muscle is also severed at its attachment to the adductor tubercle. This affords access to the contents of the popliteal space. The popliteal artery and vein are readily drawn

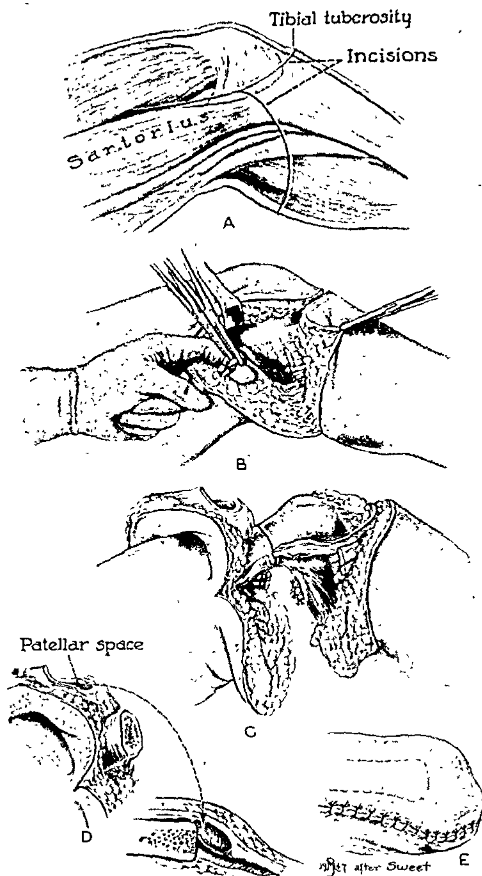


FIGURE 47. Technique of the Callander amputation *A*, Locations of lines of incision *B*, On the medial side the hamstring muscles have been divided, and the popliteal artery and vein are exposed for ligation. *C*, All structures have been divided down to bone. The patella has been excised. Line of incision in periosteum at site of division of femur. *D*, End of divided femur to be fitted into patellar space. *E*, Completed operation (Redrawn from Callander: J A M A , Vol. 110.)

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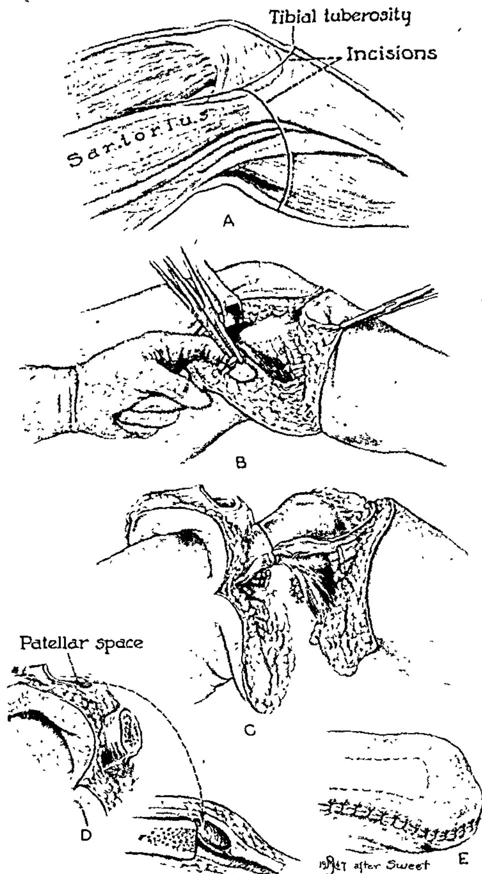


FIGURE 47. Technique of the Callander amputation *A*, Locations of lines of incision *B*, On the medial side the hamstring muscles have been divided, and the popliteal artery and vein are exposed for ligation *C*, All structures have been divided down to bone The patella has been excised. Line of incision in periosteum at site of division of femur. *D*, End of divided femur to be fitted into patellar space. *E*, Completed operation. (Redrawn from Callander: J.A.M A., Vol. 110.)

into the wound and ligated and divided. The tibial and peroneal nerves are likewise drawn into the wound and ligated and divided.

On the lateral side the fascia lata and the biceps tendon are divided at their insertions, and the posterior skin-fascia flap is dissected from the gastrocnemius muscle. Anteriorly, the patellar tendon and joint capsule are divided to form the anterior flap containing the patella. The patella is excised completely, using care to preserve the tendon of the quadriceps extensor muscle. The synovia is not removed. The femur is divided with a saw through its cancellous portion just proximal to the adductor tubercle. The cut end of the femur is rounded, and all fringes of periosteum are removed. The skin flaps fall loosely together and may be closed with skin clips or sutures.

Since none of the tendons or fascias is sutured at the severed end of the stump, the contracture of the muscles soon reduces the redundant skin flaps and fixes the severed end of the femur in the socket left by removal of the patella. As healing progresses the posterior skin flap gradually retracts until the suture line reaches a posterior position.

This operation produces an end-bearing stump.

Technique of Supracondylar Tendoplastic Amputation (Kirk)

This technique is recommended when amputation is done just above the femoral condyles. Long anterior and short posterior flaps are made as shown in Figure 48. The anterior incision passes through the quadriceps tendon at its attachment to the patella. The quadriceps tendon is included in the anterior flap. The skin is not separated from this flap. The joint membrane is cut away from beneath the tendon. The fascia posteriorly is cut 1 cm. longer than the retracted skin flap. The hamstring muscles are severed so that they will retract to the saw line.

At a point above the condyles through the upper portion of the cancellous bone, a circular cut is made in the periosteum, and the bone is denuded of periosteum downward from the cut. The bone is cut across through the denuded area about 0.4 cm. below the cut periosteum. The end of the bone is smoothed with a rasp.

The femoral vessels are isolated and ligated with chromic catgut. The sciatic nerve is pulled down, ligated and severed below the ligature and allowed to retract.

The anterior tendon muscle flap is sutured to the ends of the hamstring muscles with chromic catgut, and the deep fascia is closed with chromic catgut. A small drain may be placed down to the muscle, although this is not necessary if hemostasis is complete. The skin is closed with interrupted sutures of silk. This method produces a smooth stump which may be used for end-bearing.

Technique of Amputation through the Thigh

The site of the bone section is chosen. Long anterior and short posterior flaps may be made, or the flaps may be made of equal length, with the scar placed in the midportion of the stump. Most modern prostheses for fitting to extremities that have been amputated at this level are side-bearing in type; therefore the location of the scar is less important. The deep fascia is included with the skin flaps.

About 8 cm. below where the bone is to be cut, the muscles are divided around the thigh. The periosteum is then cut about the bone in a circular fashion and with a curet is removed downward from this line a short distance. About 0.4 cm. below the circular cut in the periosteum, the bone is divided with a saw.

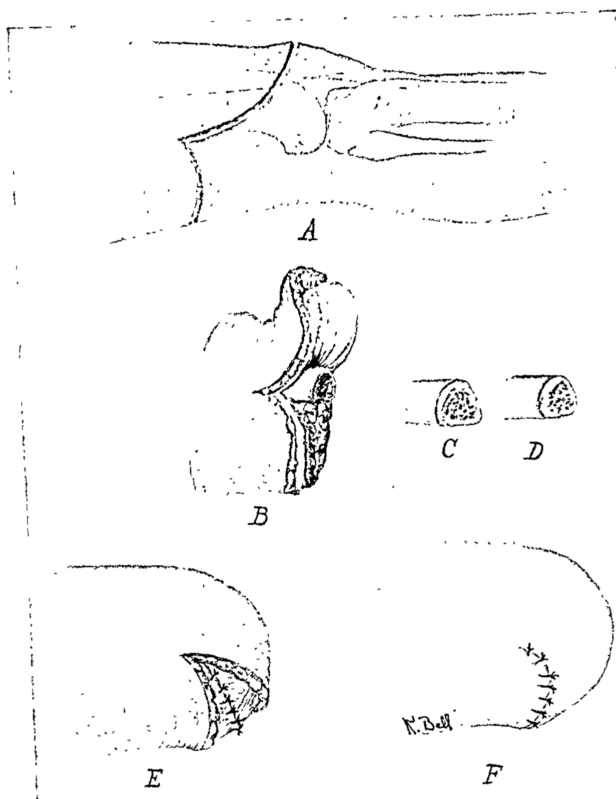


FIGURE 48. Steps in the technique of the supracondylar tendoplastic amputation of Kirk (Redrawn from Lewis' Practice of Surgery, W. F. Prior Co.)

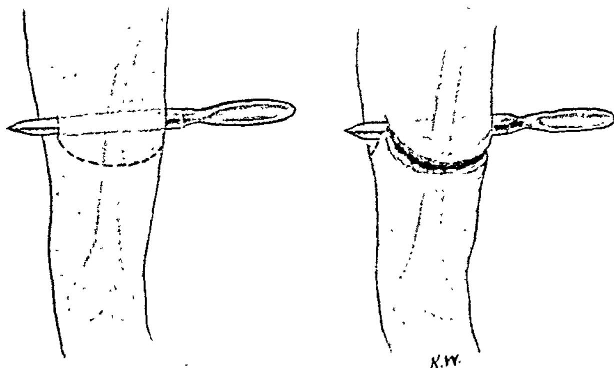


FIGURE 49. A method of rapid thigh amputation.

The important nerves are then drawn down, ligated and severed below the ligatures and allowed to retract. All bleeding vessels are ligated with fine chromic catgut.

The muscles are grouped about the bone end and to each other with a purse-string suture of chromic gut or with multiple mattress sutures of the same material. The deep fascia is carefully sutured over the grouped muscles. This fascia is the normal envelope of the muscle and should be used to cover the stump end when possible.

Closure of the skin is best made with interrupted sutures of silk. A rubber tissue drain is inserted between sutures down to the muscle near each end of the incision. The drain is removed when the stump is first dressed in twenty-four hours.

Figure 49 shows an old but still occasionally useful method of midthigh amputation for those patients whose general condition warrants as expeditious a procedure as possible. Anterior and posterior flaps are formed at the same time the muscles are severed by passing an amputating catlin through the thigh anterior to the femur, with the sharp edge of the blade facing distally and sweeping the blade anteriorly and distally to form the anterior flap. The blade is then passed behind the femur, and the knife is passed in a comparable posterior-inferior direction to form the remaining flap. Hemostasis is accomplished after the flaps have been formed. After sawing through the bone, the major portion of the amputation is completed and only the flap closure remains.

Technique of Disarticulation at the Hip or Amputation through the Femoral Neck

The method of Huggins is suitable for this operation. He emphasizes the importance of not leaving any redundant muscle or skin in hip-joint amputation. After

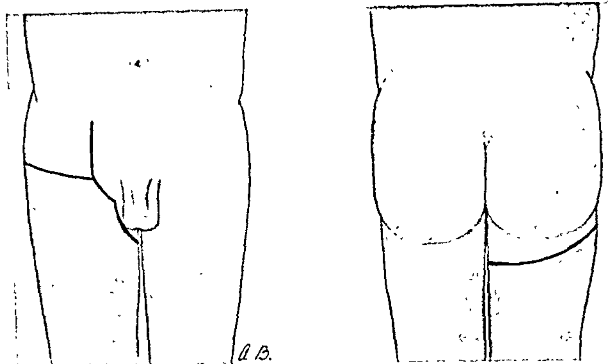


FIGURE 50 The incisions of Huggins for amputation through the femoral neck or disarticulation at the hip. (Redrawn from Orr: Modern Methods of Amputation, C V. Mosby Company)

healing, the stump must be smooth. Loose flabby skin or excess muscle interferes much with fitting of an artificial limb.

The incision is made as shown in Figure 50. That portion over the femoral vessels is made first and the vessels divided between strong ligatures. It is then extended inward for a short distance along Poupart's ligament, then downward and backward 8 to 10 cm. below the perineum, and continued around the thigh to the lower end of the vertical incision. A skin flap with the deep fascia is dissected up to a level with the hip joint.

The muscles are divided close to the bone. Bleeding vessels are clamped as they are divided. Amputation may be done through the neck with a Gigli saw, or the head disarticulated by dividing the joint capsule. This is usually done before the hamstrings and gluteus maximus are cut.

The sciatic nerve is severed high to prevent a tender neuroma near the ischium, which is the weight-bearing point. All nerves are treated as in other amputations. A portion of muscle is sutured over the acetabulum to prevent the skin at this point forming a sulcus after healing.

The skin flaps as outlined will not fit and must be shaped as the closure is made. Suturing is begun with the vertical incision and continued outward between the postero-internal flap and antero-external flap. When the outer portion of the suture line is reached, a V-shaped section must be cut from the lower flap to effect a fit. Liberal drainage is instituted. A snug dressing is applied to prevent collection of blood and serum beneath the flap.

Technique of Hindquarter (Interinnomino-abdominal) Amputation (Figs. 51, 52, 53, 54)

The indications for such a disabling operation must be considered carefully. Only those patients who cannot be treated adequately by other methods should be

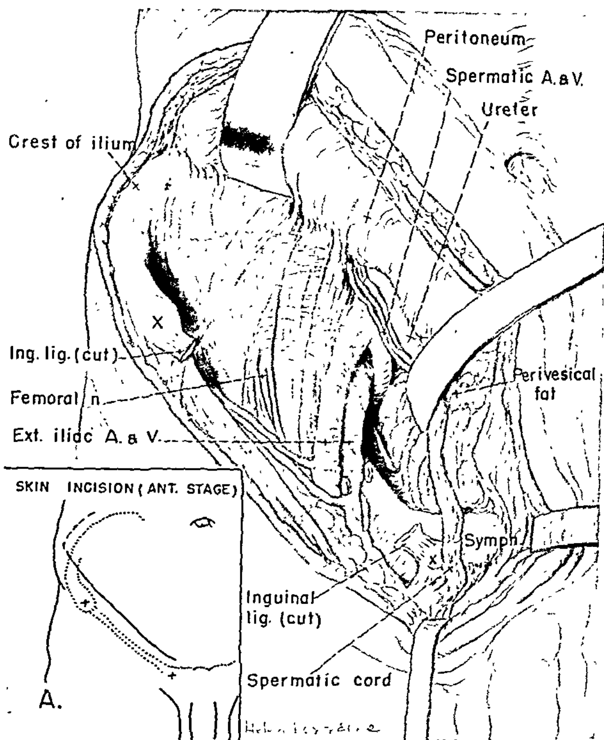


FIGURE 51 Hindquarter amputation. Inset shows line of anterior incision. The abdominal wall, abdominal contents and spermatic cord are retracted medially to expose the iliac vessels for ligation and dissection (Horsley and Bigger· Operative Surgery. C. V. Mosby Company.)

subjected to this operation. In general, the operation is done for tumors involving the ilium, pubes or upper femur in which malignancy is either proved or strongly suspected.

Dangers and Safeguards. Since this is an operation that may cause hemorrhage and shock, it is imperative that the patient have careful preoperative preparation. Because of the proximity of a portion of the incision to the anus, careful local preparation and draping are mandatory to avoid infection. Several liters of blood should be available for transfusion during the operation. Antibiotics should be used. A mortality rate of 22 per cent in sixty-four amputations has been reported by Gordon-Taylor

and Monro. Coley and Higinbotham recorded a mortality rate of 3.7 per cent in twenty-seven patients.

Technique. The patient should be placed on the table on his back (Morton) or slightly turned toward the normal side (Gordon-Taylor). If placed on his back, he must be turned for the posterior part of the operation. It is wise to have the extremity controlled by an assistant. An anterior incision is made from the symphysis over the pubic crest along the inguinal ligament and iliac crest to the posterior-superior spine. Through this incision the dissection is extended extraperitoneally. Division of the

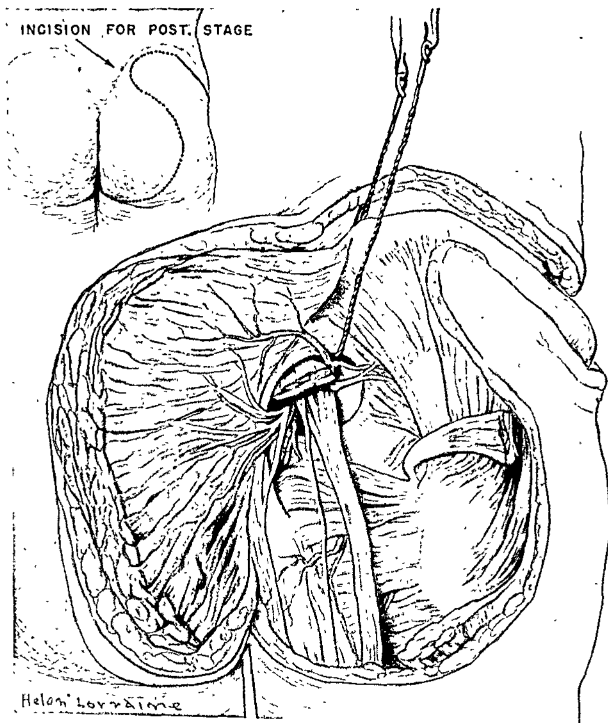


FIGURE 52. Hindquarter amputation (*continued*). Inset shows line of posterior skin incision. The
een
V.

inguinal ligament permits easy exposure of the iliac vessels. The peritoneum, ureter and vas deferens are retracted medially. The external iliac artery and vein are doubly ligated with heavy chromic catgut or silk. The distal ligature should transfix the vessel. All bleeding vessels should be ligated as the dissection proceeds. The rectus abdominis is divided at its insertion to the pubic bone, and the symphysis is divided.

The posterior incision is extended from the posterior end of the anterior incision across or slightly anterior to the trochanter and across the posterior and inner surface of the thigh to the beginning of the anterior incision at the symphysis. The gluteus maximus is dissected free and reflected backward. This muscle with its blood supply should be preserved attached to the skin when not invaded by tumor. The gluteus medius is divided to expose the sciatic notch posteriorly. After freeing the medial portion of the ilium of its overlying strutures, a Gigli saw may be passed through the sciatic notch with long forceps. The iliac bone is divided external to the sacroiliac joint. A chisel may be used when necessary.

The pelvis can now be opened. The iliopsoas, piriformis and levator muscles are divided. Injury to the rectum must be avoided carefully. The sciatic nerve trunks are ligated and divided. The entire part may now be cut away. The small portion of ilium remaining may be disarticulated at the sacroiliac joint if desired.

The gluteus maximus, if remaining, makes a good pelvic covering. The muscle

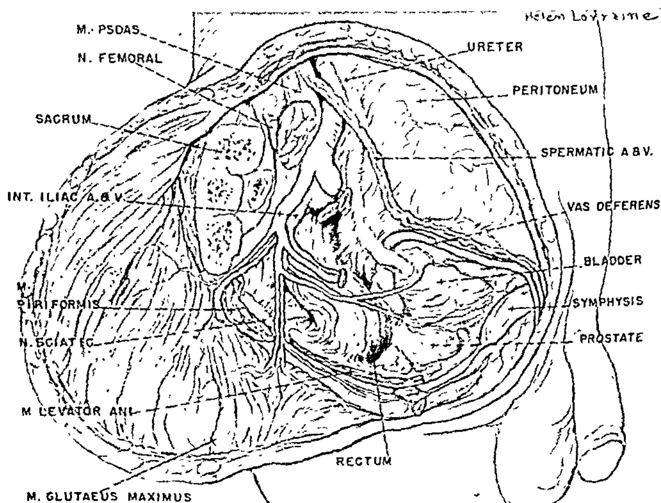


FIGURE 53 Hindquarter amputation (*continued*) The amputation has been completed except for closure of the wound The various structures exposed are labeled (Horsley and Bigger Operative Surgery C V Mosby Company)

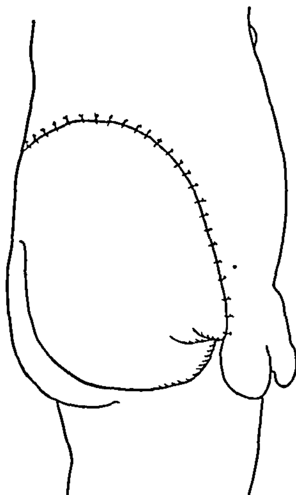


FIGURE 54. Hindquarter amputation (*concluded*). The sketch shows the location of the line of wound closure. (Horsley and Bigger: Operative Surgery. C. V. Mosby Company.)

is sutured with catgut and the skin with silk. If suffic'ent skin is available for closure, the skin flaps may be shaped to fit. A portion of the wound may be left to granulate when necessary, to be skin grafted later (Morton). Drainage of the wound is advised for two or three days. A firm dressing is applied.

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CHAPTER 5

The Skin and Subcutaneous Tissues

CLOSURE OF SKIN DEFECTS

SMALL defects in the skin may frequently be closed after simple excision of the denuded or scarred area. By undercutting and sliding the skin or by making relaxation incisions, larger defects may be closed. *If the defects are too large or improperly located for either of these methods,* skin grafts or pedicled flaps are used.

Methods of closing angular, oval, round, triangular, square and rectangular skin defects are best shown by illustration (Figs. 55, 56).

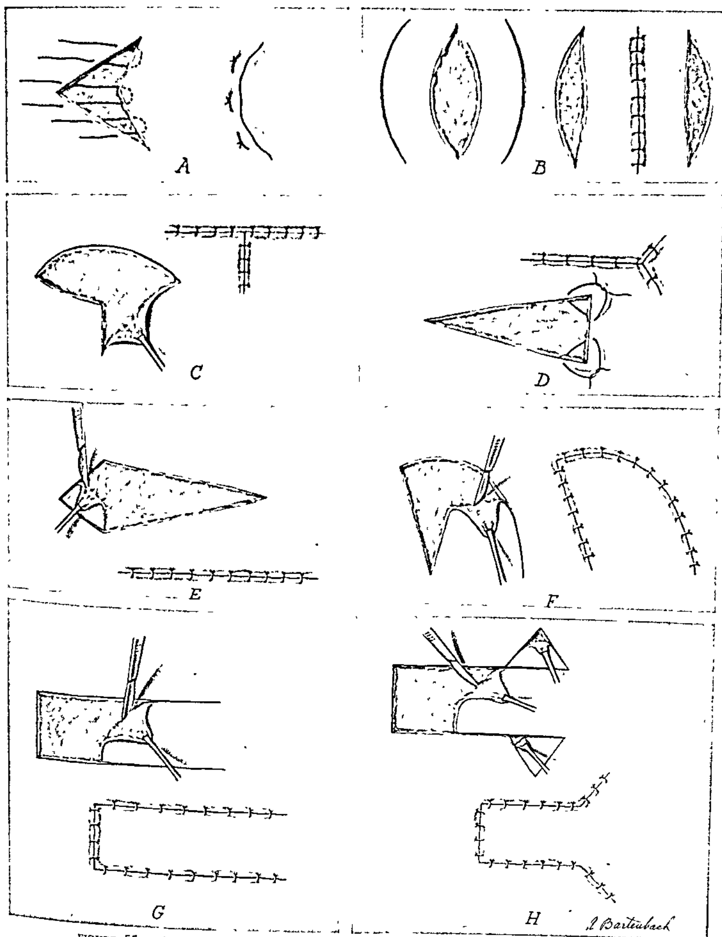
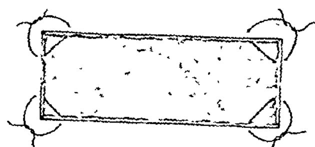
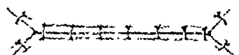
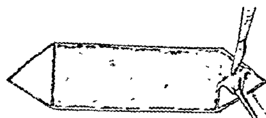
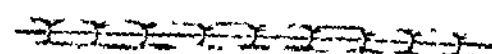


FIGURE 55 *A*, Method of closing an angled wound *B*, Bilateral relaxation incision to close an elliptical defect. *C*, Another method of closing an elliptical defect with triangular flaps. *D*, Method of closing a small triangular defect *E*, A second method of closing a triangular defect *F*, A third method of closing a large triangular defect *G*, A method suggested for closure of a square defect. *H*, A second method of closing a square defect (Redrawn from Davis and Traut. Lewis' Practice of Surgery, Vol V.)

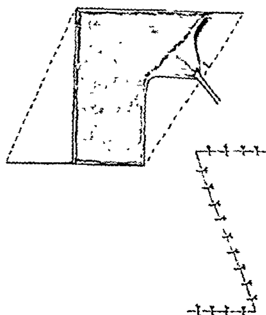
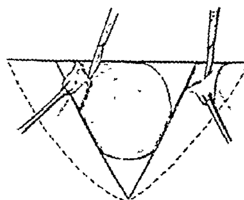
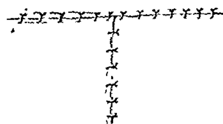





FIGURE 56 A, Suitable method of closing a comparatively small rectangular defect B, Closure of rectangular defect by cutting away triangles of skin at the ends C, Closure of rectangular defect with flaps forming a reversed Z D, Closure of circular defect E, Closure of circular defect by removing triangles of skin (Redrawn from Davis and Traut Lewis' Practice of Surgery, Vol. V.)

SKIN GRAFTS

General Considerations

Transplanted skin from the patient himself is called an *autograft;* from another person of the same species, an *isograft* or *homograft;* and from a different species, a *heterograft* or *zoograft.* The autograft is the only one that can be used with assurance of satisfactory results. Grafts from one identical twin to another may be successful.

Skin grafts may be divided into thin, intermediate and thick types. Types of *thin grafts* include the small epidermic graft of Reverdin, the thin split graft of Ollier-Thiersch and the implantation grafts of Braun-Wangensteen. These grafts consist chiefly of the epidermic layer with usually a thin layer of corium.

The *intermediate grafts* are the split grafts of Blair and Brown and the calibrated grafts of Padgett. These grafts are usually made one half to three fourths of the full thickness of the skin.

Types of *thick grafts* are the small deep graft of Davis and the full-thickness Wolfe-Krause graft. These grafts include all layers of the skin.

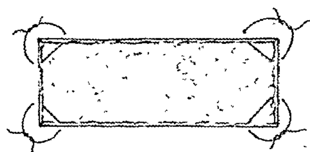
During recent years the technique of cutting skin grafts has been simplified greatly by the use of instruments designed for this purpose. Both the hand-operated, drum type of dermatome, such as that developed by Padgett, and the electric-driven models with an oscillating blade are useful and easy to use.

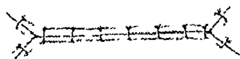
Dangers and Safeguards

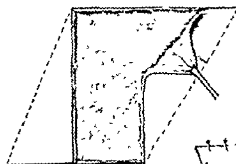
The area to be grafted should be *free from active infection.* Grafts placed in grossly infected granulations are usually not successful. Acute skin eruptions and acute infections, producing systemic reactions, are contraindications to skin grafting. Warm, mildly antiseptic moist dressings will usually remove superficial infections in a few days. The area from which grafts are to be removed is prepared as carefully as for any major operation. Hirschfeld and his associates believe that intramuscular injections of penicillin following skin grafting reduce the percentage of loss of grafts due to infection.

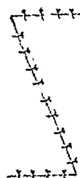
The *general physical condition* of the patient should receive special attention. Nutritional deficiencies, anemia and any bleeding tendency should be corrected. Chronic disease such as syphilis, diabetes and nephritis may prevent successful skin grafting or other plastic operation.

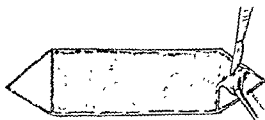
Bleeding from the surface to be grafted may be troublesome. This is especially true if extensive scars have been excised. The success of a skin graft depends much upon careful hemostasis. Clots formed beneath grafts prevent accurate contact of the graft and predispose to infection. Ligatures used to control bleeding are foreign bodies and should be reduced to a minimum. When ligation of vessels is necessary, the finest catgut should be used. Warm moist packs applied with pressure will usually control oozing. Bleeding from the donor areas of grafts cut with the dermatome has been found by Dr. David W. Robinson to average 46 gm. of blood per dermatome drum of 200 sq. cm. The greatest loss measured was 590 gm. for a 9 drum area. The tendency to bleed was greater with thick grafts taken from the buttocks and abdominal wall, and in young persons

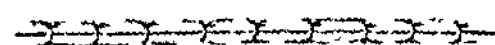


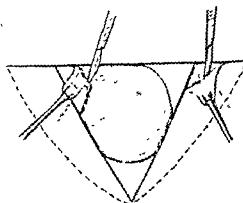
















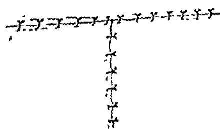


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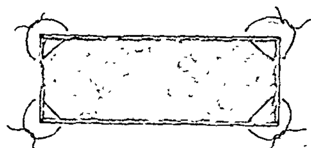
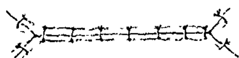
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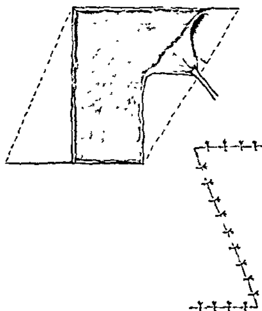
Dangers and Safeguards

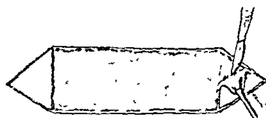
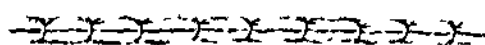
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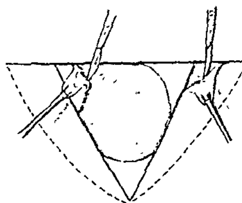
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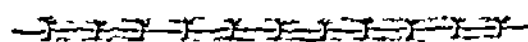
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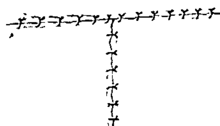


FIGURE 56 *A*, Suitable method of closing a comparatively small rectangular defect *B*, Closure of rectangular defect by cutting away triangles of skin at the ends *C*, Closure of rectangular defect with flaps forming a reversed Z *D*, Closure of circular defect *E*, Closure of circular defect by removing triangles of skin (Redrawn from Davis and Traut Lewis' Practice of Surgery, Vol. V.)

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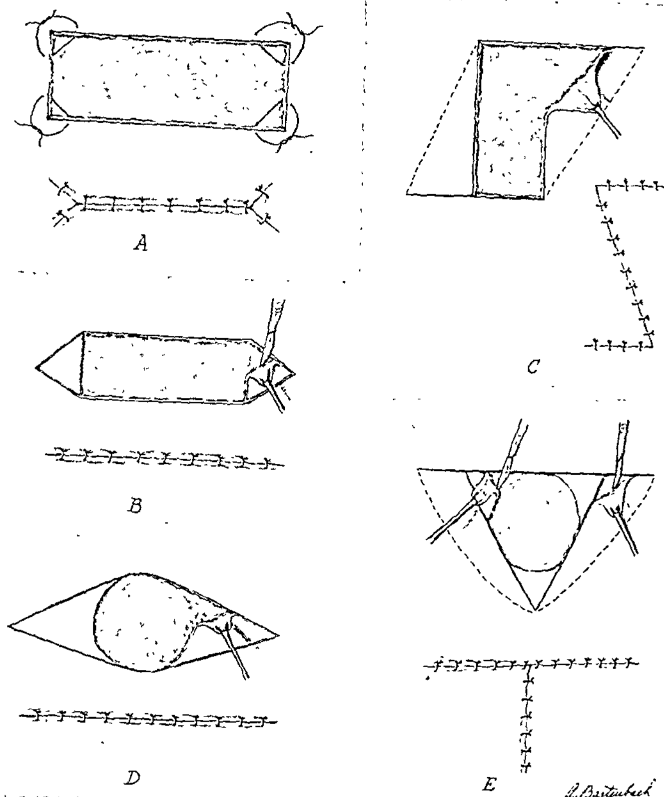


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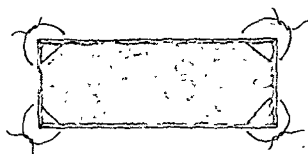
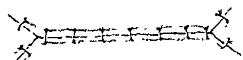
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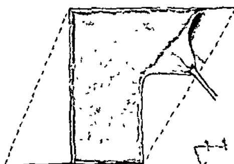
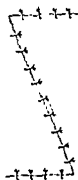
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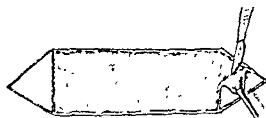
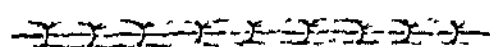
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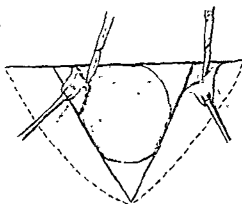
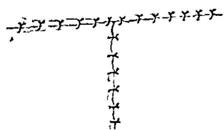
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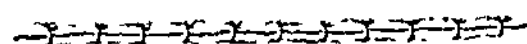



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cosmetic results. These grafts are also not suitable to cover areas about joints, where contractures are important, or on the hands and feet, where there is more or less continuous pressure and friction.

Technique of Operation (Fig. 57). Local anesthesia is suitable in many cases, especially when the area to be grafted is small.

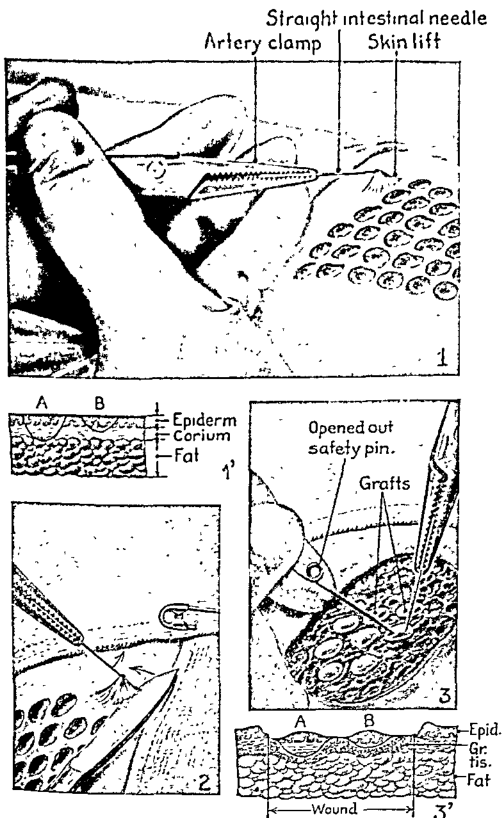


FIGURE 57 Method of cutting small deep grafts *A* and *B* in *1'* show the difference in thickness between the small deep graft and the thinner Reverdin graft (Davis and Traut Lewis' Practice of Surgery, Vol. V, W. F Prior Co , Inc.)

Accurate contact between the graft and the surface to be covered is essential. If the graft is floated up with blood or serum, failure is probable. Sufficient pressure is applied over the graft to hold it in contact with the grafted surface. Immobilization of the graft is also essential. A graft that slips or is frequently shifted will not heal. Rest can be maintained by splinting the part, by pressure dressings and by suturing the graft in place.

The use of *strong antiseptics* on either the donor or recipient area may be harmful. Careful cleansing of the skin with soap and water and adequate preparation of the field to be grafted make antiseptics superfluous. When grafts are removed, they should be applied immediately to the prepared surface, or they should be kept moist in gauze saturated with physiologic sodium chloride solution until ready for use. Grafts should never be permitted to become dry.

After removal of a graft the donor area should be covered with a bland ointment. Cannon and Cope demonstrated a definite delay in the rate of regeneration of the epithelium when such substances as tannic acid, silver nitrate, gentian violet, triple dyes, and triethanolamine solutions were used on the donor area.

Hair will grow on thick grafts taken from hair-bearing areas. This should be kept in mind when placing grafts where hair may be objectionable. Skin varies in thickness, texture and color, depending upon the location and the age of the patient. Transplanted skin should, if possible, resemble the skin of the area to be grafted. For repair of facial defects Brown and Cannon recommend the use of full-thickness grafts taken from the neck and clavicular region. Such grafts nearly match the color of the normal face, are soft and pliable and produce good function.

Webster emphasizes the point that reparative processes in wounds continue for months and even years, and grafts which may not appear satisfactory soon after operation may show vast improvement in two or three years.

Local *anesthesia* may be used in many cases when grafts are small and the area to be grafted requires little or no local preparation. When large scars are to be excised or extensive operative preparation of an area is necessary, general anesthesia is preferable.

The Reverdin Graft

This type of graft includes the epithelial layer with as little of the corium as possible. It is difficult to cut and has no advantage over the small deep grafts described below.

Technique of Operation. A cone of skin is picked up with the tip of a sharp needle which penetrates the epidermis (Fig. 57). The base of the cone is cut across with a sharp scalpel or razor blade. The method of applying the graft is described below for *small deep grafts.*

Small Deep Graft of Davis

The Davis graft is suitable for areas covered by clothing. The results are efficient but somewhat unsightly. *This type of graft is especially suited for the granulating* wound not in the best condition, since the percentage of "takes," even in the presence of some infection, is high. Sound healing results with some contracture.

It is unwise to use the Davis graft on an exposed surface because of the poor

cosmetic results. These grafts are also not suitable to cover areas about joints, where contractures are important, or on the hands and feet, where there is more or less continuous pressure and friction.

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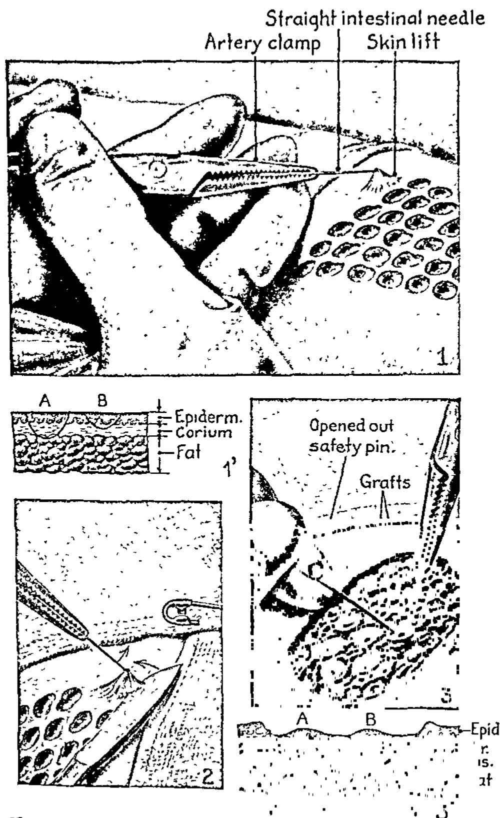


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A straight needle is grasped in a hemostat and used to lift a small cone of skin. The base of the cone is cut across with a sharp knife or safety razor blade. A properly cut graft is round or oval, between 0.2 and 0.5 cm. in diameter, thick at the center and thin at the margin. The full thickness of the skin is removed at the center of the graft. A narrow rim of skin, about 0.5 cm. wide, is left between the pits produced by cutting away the grafts.

Grafts may be placed immediately on the granulating surface or placed in gauze wet with physiologic sodium chloride solution until all grafts are cut. If they are transferred directly to the wound, a change of needles is advisable to prevent carrying infection from the granulating surface to the fresh wounds of the donor area. Grafts are placed about 0.5 cm. apart on the area to be grafted and firmly pressed in place by a pledget of gauze.

As a dressing, Xeroform gauze or rubber tissue may be used. For small areas, strips of flamed adhesive tape make an excellent dressing. These are placed in strips 1.5 cm. wide with a narrow space left between the strips for drainage. A change of dressing may not be necessary for ten days, after which time the grafts will have adhered if successful. If dressed sooner than ten days, care must be exercised to avoid disturbing the grafts. If any infection is present, dressings are kept moist with physiologic sodium chloride solution. *Rest is essential for success.* Splinting of an extremity is advisable when large areas are grafted.

The Ollier-Thiersch Graft

This graft should include the epithelial layer and tips of the papillae of the corium. When it is properly cut, bleeding will be slight.

Ollier-Thiersch grafts are more commonly used than other types chiefly because they are more easily cut and applied and the percentage of "takes" is high. They are usually taken from the thigh, but may be cut from the arm, abdominal wall, chest wall or back. They may be cut in large sheets or relatively narrow strips. If multiple grafts are used, they should overlap at the edges and wound margins. Excess skin has been preserved successfully in sterile saline solution in a refrigerator and used on the *same patient later.*

These thin grafts are suitable for covering large areas, especially on flat surfaces, and for replacing mucous membrane of the mouth, eye socket and nose. They are also used as stent or inlay grafts to be described later. They "take" well and may grow in the presence of mild infections.

Contractures may develop after Ollier-Thiersch grafts. Where this is likely to be *important, thicker types of graft are preferable.*

Technique of Operation (Figs. 58, 59). A long, sharp, specially made knife or razor with rounded points may be used for cutting the grafts. Small grafts may be cut with a safety razor blade held in a hemostat. The skin is held taut, usually by two thin, sterile boards in the hands of the assistant and operator. Dry gauze pressed firmly on the skin surface by the assistant and operator will often be sufficient to flatten the surface and make the skin tense for cutting. The suction retractor of Blair (Fig. 60) is useful when large grafts are being cut. The blade of the knife is kept moist by dripping salt solution on the area as the graft is cut.

The graft is placed at once on the area to be grafted. Wrinkles and curled margins

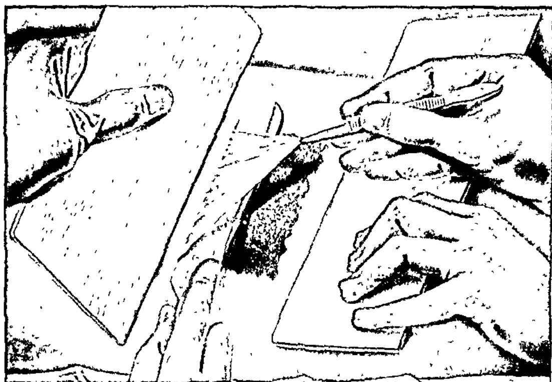


FIGURE 58. A method of cutting an Ollier-Thiersch graft. The skin is held flat with thin sterile boards. As one board is dragged along, the graft is cut with a sawing motion of the razor. The graft includes the epithelium and only the tips of the papillae of the corium. (Davis and Traut: Lewis' Practice of Surgery, Vol. V, W. F. Prior Co., Inc.)

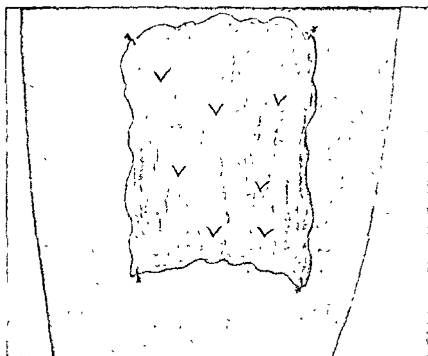


FIGURE 59 The Ollier-Thiersch graft has been carefully spread out and placed on the area to be grafted. Note cuts in graft for drainage. Sutures are placed at the corners of the graft to aid immobilization. (Davis and Traut. Lewis' Practice of Surgery, Vol. V, W F. Prior Co , Inc.)

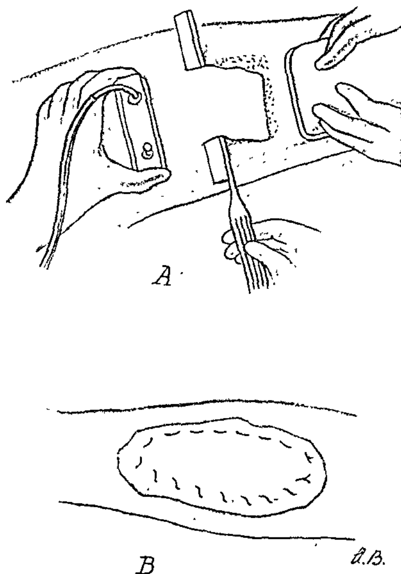


FIGURE 60. Split graft A, With the use of the Blair suction retractor, a large split graft is cut B, The graft is sutured into the defect with horsehair under approximately normal tension. The graft is punctured in numerous places for drainage. (Redrawn from Blair and Brown. Surg, Gynec. & Obst., Vol 49)

are spread out with fingers and instruments. Edges of multiple grafts are overlapped. If air bubbles are present beneath the graft, small holes are cut to permit the escape of the air and to drain away any accumulation of serum.

Stitches of fine silk may be used to aid in the fixation of grafts. Gauze impregnated with 3 per cent Xeroform held in place by sterile marine sponges makes a good dressing. For small areas, strips of zinc oxide adhesive plaster are satisfactory to hold grafts in position when they are applied in ½-inch strips to permit drainage. Adhesive plaster may be sterilized in a steam sterilizer in the roll or flamed before application.

The dressings of clean wounds need not be changed for ten days. Grafts will adhere in this length of time. If there is much drainage, the outer dressings should be carefully renewed before the expiration of the ten-day period. The dressings should be kept moist with physiologic sodium chloride solution. After the grafts have adhered to the wound surface a dressing of boric acid ointment, Xeroform gauze or a mild dusting powder may be used. When healing is complete, light massage is indicated.

The Braun-Wangensteen Implantation Grafts

Implantation grafts may be successfully used when other methods would probably fail. They grow well in the presence of infection and unhealthy-appearing granulations. They are especially suited for osteomyelitis cavities, chronic empyema cavities and decubitus ulcers with undermining of the skin. The cosmetic results of this type of graft are not the best.

Technique of Operation (Fig. 61). An Ollier-Thiersch graft is cut in the usual manner. Wangensteen uses ordinary dinner plate knives to hold the skin taut while the graft is being cut. From the large graft, small pieces of skin are cut 2 to 4 sq. mm. in size. With an ordinary straight sewing needle grasped in a hemostat with the eye of the needle at the free end, the small squares of skin are pushed obliquely into the granulation tissue until the graft disappears from sight. An entire granulating area is seeded with the small grafts by placing them about 1 to 1.5 cm. apart.

The grafted area is covered with petrolatum gauze. In three or four days the wound is treated with Dakin's solution. In about eight days the grafts make their

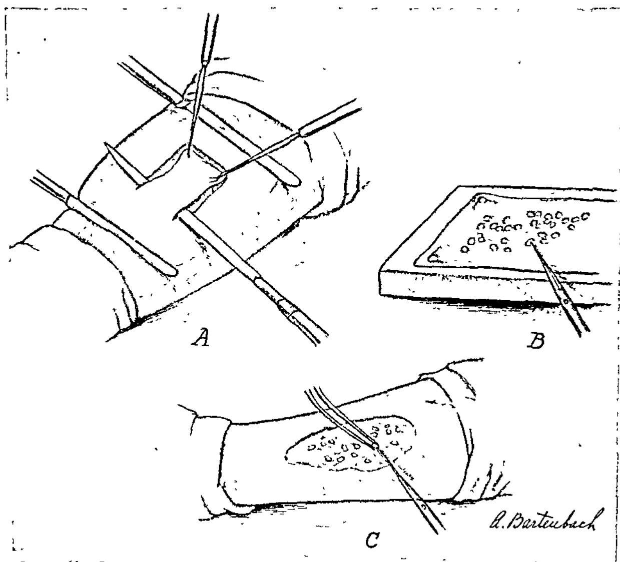


FIGURE 61 Implantation method of skin grafting. *A*, Cutting a Thiersch graft. *B*, The Thiersch graft is cut into small fragments *C*, With the blunt end of a sewing needle the small grafts are pushed into the granulation tissue until they disappear from sight. (Redrawn from Wangensteen: Surg., Gynec. & Obst., Vol. 50)

appearance as small whitish spots. The percentage of "takes" is high, and healing is rapid.

The Thick Split Graft of Blair and Brown

This graft is thicker than the Ollier-Thiersch graft. It may be cut in different thicknesses, usually one third to three fourths of the full thickness of the skin. Large grafts are readily cut by using the method described by Blair and Brown. A high percentage of "takes" may be expected. There is less danger of contraction than with the thinner Ollier-Thiersch graft.

Technique of Operation (Fig. 60). The field to be grafted is prepared by slicing away granulations and scars down to a firm yellow base. The wound is outlined with a scalpel to give it definite margins. After slicing the scar away, layer by layer, the deep scar yields, and the defect will expand to almost its original size.

Blair and Brown use a long, thin knife made of razor steel to cut the grafts. An ordinary barber's razor with rounded heel and toe may be used, but large grafts cannot be cut with this instrument.

The graft is cut from a surface made flat by pressure applied with thin boards or the margins of porcelain pans. In order to cut large grafts with accuracy, Blair has designed a suction retractor of three different lengths to lift and hold the skin while the graft is being taken. Some practice is necessary before this instrument can be skillfully used. A thin layer of petrolatum is applied to the skin of the donor area and wiped off, leaving just enough for lubrication. Too much petrolatum allows the retractor to slip, and too little causes it to drag and produce ecchymosis. While the skin is held taut at one end, the retractor is applied and moved slowly along the skin surface as the graft is cut. If grafts are cut from the abdominal wall or other uneven surfaces, the skin is slightly lifted and continuous tension applied.

Large grafts are preferable to cover completely the area to be grafted. The graft is immediately applied to the wound bed and held in place under slight tension by continuous sutures of fine silk along the wound margins and mattress sutures through the graft to prevent slipping and to maintain contact with the wound surface. Stab wounds are made in the graft for drainage.

Blair and Brown list the factors which are most important in promoting a quick, sure "take" as absence of virulent infection, fixation, pressure, and provision for drainage. As a dressing for the graft, 3 per cent Xeroform gauze pads and marine sponges are satisfactory for most areas. The sterile marine sponges are applied moist so that they will mold to fit the part. The entire dressing is held in place by bandage or adhesive plaster.

In clean cases with a healthy-appearing wound it may not be necessary to change the dressing for ten days. If there is any doubt about the progress of the healing, the dressing may be removed at any time. If serum or blood has collected beneath the graft or if there is evidence of infection, the area is drained by cutting away the section of the graft which is separated from the wound bed. Moist dressings of physiologic sodium chloride solution are used to promote drainage.

The Calibrated Graft of Padgett

Padgett has designed an instrument (dermatome) for cutting "calibrated intermediate skin grafts" of uniform thickness at any depth desired. The details of the

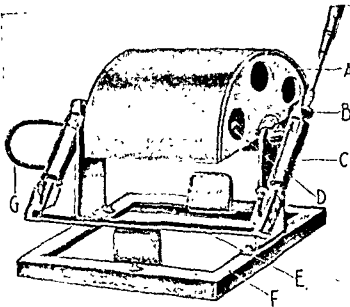


FIGURE 62. Details of the Padgett dermatome *A*, Support of drum. *B*, Screw calibrated to 0 002 inch. *C*, Shaft into which calibrated screw turns *D*, Shaft of drum held in the hand while cutting graft. *E*, Holder for knife blade. *F*, Base *G*, Handle by which the shaft holding the knife is worked backward and forward. (Padgett: Surg., Gynec. & Obst , December, 1939. By permission of Surgery, Gynecology and Obstetrics)

instrument are shown in Figure 62. A half-drum is constructed so that a movable knife fixed at a definite distance from the drum cuts the grafts. The desired thickness of the graft is obtained by adjusting a calibrating screw. A sheet of skin 11 by 20 cm., which is the size of the drum surface, may be easily cut in uniform thickness from donor areas which present difficulties by other methods. Grafts may be cut to pattern by painting out the skin area not to be removed, with a solution of talc and ether. This solution prevents adherence of the skin to the drum.

The thickness of the graft to be removed varies with age, sex and location. The skin of young children is thin, and grafts must be cut accordingly. In general, the skin of the female is thinner than that of the male. Skin over the abdomen of a woman is thin after repeated pregnancies. The skin of the inner surface of the thigh and of the upper arm is thinner than elsewhere on the body surface from which intermediate grafts may be conveniently taken.

Grafts cut with the dermatome generally vary in thickness from 0.25 to 0.71 mm , depending upon the factors listed above and the type of graft needed to cover the defect. As a general rule, the thicker grafts heal with less contraction than the thinner types.

Padgett states that this type of graft shows few blisters or local areas of necrosis, may be cut to pattern if desired, the ultimate contracture is reduced to a minimum, good protection is offered, the appearance approaches that of the normal skin, the donor area heals quickly, the postoperative period is relatively short, and the usual lesions treated may be corrected in one operation.

Technique of Operation (Fig. 63). Adhesive cement is applied to both drum and skin. The cement holds the skin in contact with the drum. The knife is set the required distance from the drum by the calibrating screw. While light traction is made on the drum, the skin is cut with a sawing motion of the knife as the drum is slowly rotated. The graft is removed from this drum with forceps and applied directly to the wound bed.

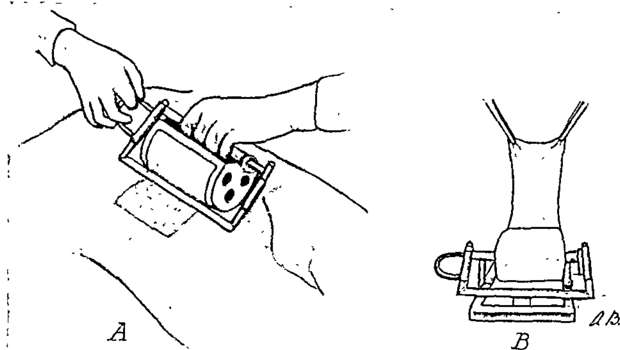


FIGURE 63. *A*, Cutting graft from abdominal wall with dermatome. *B*, Removing calibrated graft from drum. (Redrawn from Padgett: Surg, Gynec. & Obst, Vol 69.)

The principles involved in fixing the graft to the wound surface, the dressings, and after-treatment do not differ in essential details from those described above for the thick split graft.

Whole-Thickness Grafts of Wolfe-Krause

Whole-thickness grafts are especially suitable for grafting about the elbow, axilla, popliteal space, groin, face, neck, eyebrows and hand because of the minimum tendency to contracture after healing. In any area where constant trauma is a factor this graft is more reliable than the thinner grafts. The thick split graft of Blair and Brown and the calibrated graft of Padgett, however, have definitely reduced the indications for the use of the whole-thickness graft.

Difficulty in cutting and a high percentage of failures are disadvantages of this graft. Difference in color and pigmentation of the healed graft as compared to surrounding skin is sometimes objectionable. Grafts should be taken from areas of similiar appearance to the skin about the grafted area. The technique of operation for the Wolfe-Krause graft is more difficult than that of other grafts, and more time is required for healing. It is usually necessary to graft the donor area with Ollier-Thiersch or other split grafts

Technique of Operation (Fig. 64). The bed for the graft is usually prepared first by excising scar, ulcer or granulation tissue down to pliable tissue. All bleeding from the graft bed must be controlled with scrupulous care. Very fine silk or cotton should be used for vessels requiring ligation. An accurate pattern of the wound is made with tinfoil, sheet rubber, oiled silk or fine-mesh gauze applied to the defect to outline its margins. The pattern is then placed on the donor area and outlined with a dye such as 5 per cent brilliant green in alcohol.

The graft is outlined with an incision through the skin. It is safe to cut the graft slightly larger than the pattern by making the skin incision 1 to 2 mm. beyond the

margin of the pattern. The slightly oversized graft will allow for shrinkage and reduce the tension at the suture line. An edge is lifted with a small dural hook or tension suture, and the skin is carefully dissected up from the subcutaneous fat with a sharp knife. A sterile gauze bandage may be used to facilitate holding the graft as it is cut

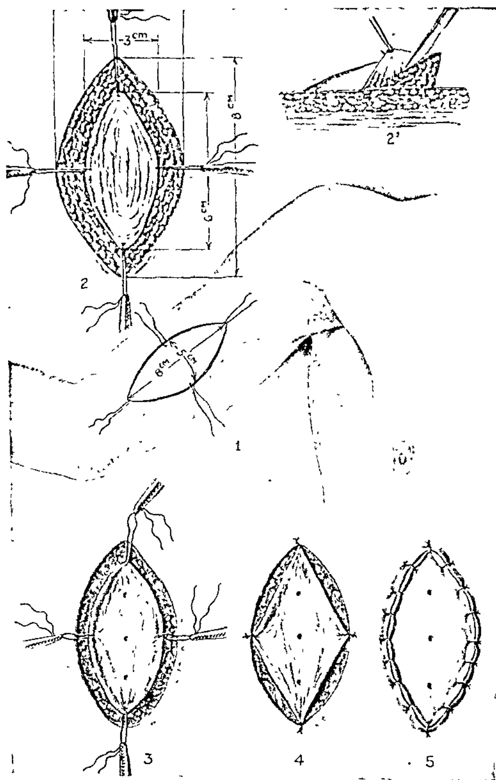


FIGURE 64 Method of obtaining a whole-thickness [illegible]

[illegible] defect with 4 sutures. 5, Suture of graft in place completed. Fine waxed silk or horsehair is used for suture material. The graft is perforated for drainage. (Davis and Traut: Lewis' Practice of Surgery, Vol. V, W. F. Prior Co , Inc)

(Fig. 65). Any fat left attached to the graft should be cut away. Avoid bruising the graft. The graft should be immediately placed upon the wound bed, but, if there is any delay, it is folded with the raw surfaces together and kept moist in gauze saturated with saline solution.

The graft is fitted into the wound and held in place with four or more interrupted sutures. Additional interrupted or continuous sutures of fine silk are used to approximate the graft accurately to the wound margins. The tension of the sutured graft should be about the same as that of the normal skin.

If the diameter of the graft is more than 3 cm., small stab wounds are made with a sharp-pointed knife about 2 cm. apart to permit drainage of serum. If the graft is placed upon an uneven surface, mattress sutures are useful to attach it securely to its bed.

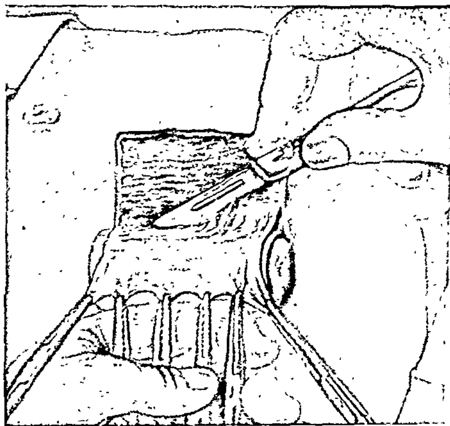


FIGURE 65. A technique for cutting a full-thickness skin graft. A roll of gauze is used to hold the skin flat and at proper tension. (Redrawn from Padgett Skin Grafting, Charles C Thomas.)

The graft is dressed with several layers of petrolatum gauze or 3 per cent Xeroform ointment gauze over which is placed a moist marine sponge cut to fit. The sponge is held in place with adhesive strips; and over this, dressings and bandage are applied with sufficient tension to take about 65 per cent of the elasticity of the sponge. Immobilization is necessary during the healing period. Splints or plaster casts are often useful.

If there is no evidence of infection, the dressing need not be disturbed for ten days, at which time the sutures may be removed. The pressure dressing is maintained for about three weeks. If blisters form, they should be opened. The grafted area is carefully protected with petrolatum gauze dressings for five to six weeks, after which gentle massage with olive oil or cocoa butter will soften the scar and increase circulation.

The donor wound is closed with sutures when possible or covered with Ollier-Thiersch or split grafts.

The Stent Graft

In certain localities small grafts of split or whole-thickness skin may be grafted by using a stent of dental modeling composition.

Technique of Operation (Fig. 66). The bed for grafting is prepared by excising the scar or by incision and undermining for relaxation. Modeling composition is softened by dipping it into warm water. A model is made to fit the prepared wound. Over this model a skin graft is snugly fitted with the raw surface outside. The stent with skin

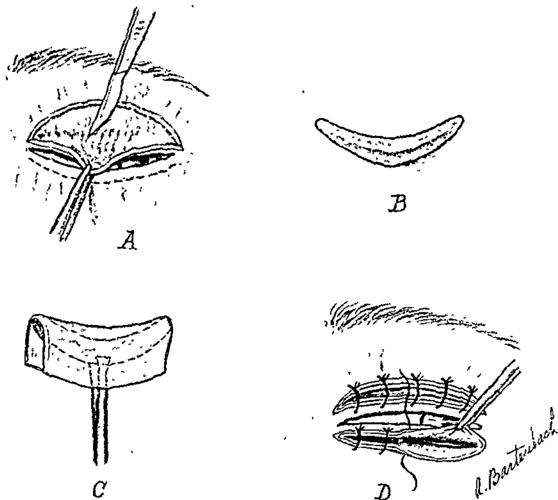


FIGURE 66 Use of stents made of modeling wax for grafting eyelids.

graft covering is placed in the prepared wound and held in position by sutures extending from one margin of the wound to the other.

PEDICLED GRAFTS

General Considerations

Pedicled skin grafts may be classified as *simple*, *compound* and *lined*. A simple graft is composed of skin and subcutaneous tissue. A compound graft contains skin, subcutaneous tissue, and bone, cartilage or muscle. A lined graft is a simple graft, the under surface of which is covered with epithelium by folding the pedicle or by applying an Ollier-Thiersch graft.

There are three general methods of pedicled grafting. These are the *French, Indian* and *Italian* or *Tagliacotian* methods. With the French method a skin graft is undercut and by sliding or advancing is made to close defects. By the Indian method, grafts are obtained from neighboring skin and transplanted into a new position by some twisting of the pedicle. Grafts taken from a distant part have been known as the Italian or Tagliacotian method. Many modifications of these types are used.

Transfer of grafts may be *immediate* or *delayed.* By the immediate method the graft is raised and implanted in its new bed as one procedure. To improve the blood supply, the graft may be raised and replaced and the transfer delayed. The transfer of a graft may be made in multiple stages from one distant part to another. For example, an abdominal graft may be attached to the hand or wrist and later transferred to the face. By such successive stages of migration, grafts may be transferred any distance from one part of the body to another. A graft for delayed transfer may be satisfactorily prepared by the tube method of Gillies.

Pedicled grafts are indicated for the repair of deep defects where skin grafts would not sufficiently reconstruct the part or when more pliability and elasticity is required than can be obtained with free grafts.

Dangers and Safeguards

In order to obtain the highest percentage of successful results, certain fundamental principles of graft transfer must be observed. The general principles involved in skin grafting are applicable to pedicle grafting. A *dry wound* is essential. Blood clots and collections of serum beneath transplanted grafts prevent healing. *Accurate contact* and *immobilization* must be secured by splinting the part and by the use of marine sponges applied to produce moderate pressure.

A prime consideration is the *circulation* in the graft. To prevent damage to the circulation during the preparation or transfer of a graft, bruising, overstretching, kinking, excess pressure, and tension must be avoided. When in doubt about the circulation, the delayed transfer method is preferable. The graft is outlined, lifted and sutured in its bed. Thin rubber protective may be placed beneath the raised graft before suturing to keep the raw surfaces apart. A single or double pedicled graft may be used, the latter having the better blood supply because of its attachment at each end.

The *optimum time for transfer* of a prepared graft is somewhat difficult to determine. Various authors have advised a wait of several weeks to several months. German, Finesilver and Davis found by experimental study that an adequate blood supply is established in tubed double pedicle skin grafts within a period of seven days. A long delay before transferring a graft is not disadvantageous from the standpoint of blood supply, but may be irksome for the patient. Davis and Traut recommend partial division of one pedicle after the lapse of seven or eight days and frequently complete the division on the ninth or tenth day. The pedicle may be severed and transferred after an indefinite period without affecting the quality of the graft. After a tubed graft has been transferred the new circulation may be tested by blocking the circulation with a rubber-shod stomach clamp, or a small rubber catheter clamped snugly about one pedicle.

The *size* of a graft should be somewhat larger than the defect it is to fill. This will

allow for shrinkage. It should also be in the *shape* of the defect to avoid useless loss of tissue and to permit accurate fitting.

Cotton or fine silk is used as *suture material*. Catgut produces more local reaction in the tissues than fine nonabsorbable sutures. To produce the best cosmetic results, the skin of the graft should be of a texture similar to that of the skin surrounding the area to be grafted. *Hair-bearing skin* should not be used except in locations where hair grows naturally. Hairy skin should not be used to correct defects in the mouth or other mucous-lined cavities.

When avoidable, grafts should not be cut to include scar tissue. Scars diminish or may completely cut off the blood supply.

The *pedicle* of a prepared graft should be as broad as possible. If a graft is to be transferred immediately, it is a good general rule to make the length not more than two and one-half to three times the width of its base. This rule may be altered if the graft contains an artery to assure adequate blood supply. A graft obtained from the immediate vicinity of the defect and cut in a direction to minimize twisting of its pedicle when sutured into a defect will aid in preserving blood supply. The blood supply of a graft may be damaged by twisting or puckering its pedicle or by transplanting it under too much tension. A graft with a good arterial blood supply may become gangrenous as a result of stagnation of the return flow of blood and lymph. Scarification or multiple punctures may relieve the congestion. Light massage in the direction of the pedicle is helpful. This complication is less likely to develop after delayed transfer of a graft.

Pedicled tubed grafts must be protected against too much *pressure*. When a double or single pedicled graft is lifted and resutured in its bed for delayed transfer, it may be dressed with 3 per cent Xeroform ointment and a marine sponge applied with light pressure.

If a *local anesthetic* is used in transferring a graft, it should be injected into the tissues adjoining the graft and not into the graft proper. The pressure of a local anesthetic within a graft might damage its circulation.

When transplanting a long tube graft, the weight of the graft must be supported to avoid the tearing out of stitches and pulling away from the graft bed.

Patients may complain of the *anesthesia* of transplanted grafts. According to Davis and Kitlowski, sensation usually completely returns in transplanted pedunculated grafts. The return of sensation may require several months.

Davis and Traut advise that the simple types of pedicled grafts can be raised and successfully shifted by almost any surgeon, but the more complicated grafts present a different problem and can be utilized successfully only by a skilled plastic surgeon.

Conclusions of Blair on Use of Long Pedicled Grafts

The conclusions of Dr. V. P. Blair, made in 1921, concerning the use of long pedicled grafts are still sound and are here presented.

About the neck and face of a man in ordinary health, regardless of age, rather long pedicled grafts can be made with little danger to their vitality, provided the return circulation is obstructed neither by gravity nor kinking or torsion of the pedicle; but in women and children the circulation is not so vigorous and equally long grafts are less likely to survive.

In any instance the chance of success is increased, *or a longer graft can be raised,* or the graft can be cut narrower and thinner, with equal chance of success, if it is first completely raised and then immediately sutured back into its original bed and the transfer to the new position delayed for a period varying from six days to two weeks.

If a graft does slough in its original bed, the extent of the area lost will be considerably less than if it had been immediately transplanted.

Sloughing of an untransplanted pedicled graft is apt to be superficial without destruction of the full thickness of the skin, while a slough occurring after transfer is more apt to involve the full thickness of the graft.

If a graft will not survive, it is a real advantage to have this fact demonstrated before removal of the scar and freshening of the edges of the defect.

Provision for a possible partial loss can usually be made in the original planning of the graft.

In the transplanted position gravity may be more favorable to venous and lymphatic drainage, but this advantage will not always compensate for other deleterious factors incident to immediate transfer.

If it becomes evident that the transplanted graft is in danger of sloughing, it is better to place it back in its original bed immediately. By so doing, not only will time be saved, but also, not improbably, a much larger part of the graft.

When a graft is to be split into two or more narrow grafts, such as to cover the eyelids or lips or to line the nose, it is safer to delay splitting the graft until the time of transplantation or to an intermediate time than to do it at the time the graft is first raised.

In a neck graft, which includes a section of the clavicle for a pedicled bone graft, the soft tissues will have a firmer attachment to the bone, and, I believe, the bone will be more resistant to infection if the transfer is delayed.

A blood clot under a graft that has been sutured back into place may be fatal to the graft. This danger is avoided by moderate pressure of dressings and use of multiple drains, to be removed in twenty-four hours.

If there is to be a raw surface left exposed on the pedicle after transplantation of the graft, it will be more resistant to infection after a delayed transfer. Certain complicated time-consuming operations are advantageously divided into two sittings by this procedure.

Occasionally, after suturing the graft back in its original bed, the transplantation will of necessity be long delayed by a low grade suture infection or an infection in the bed. Any of these occurrences is an *incident rather than a calamity* and is to be guarded against by not drawing the sutures tight, by removing them early, by free drainage and by ordinary cleanliness.

When any part of a graft sloughs while in its original bed, that part, no matter how superficial the slough, should not be transplanted.

Another disadvantage of the delayed method, more apparent than real, is that it involves two operations instead of one.

Even delayed transfer has not been successful in every case.

Technique of Immediate Transplantation of Pedicled Grafts (Figs. 67, 68)

The graft bed is carefully prepared by cutting away scar tissue and freshening and shaping the margins. A graft of skin and subcutaneous tissue is cut as nearly as

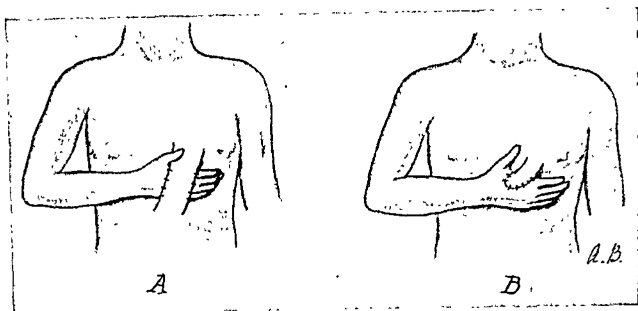


FIGURE 67. Method of applying pedicled graft to hand. *A*, Double pedicled flap to cover large defect on back on hand. *B*, Single pedicled flap to cover small defect on hand.

possible to pattern, slightly larger than the defect to be filled. All bleeding is carefully controlled. The graft is sutured into the defect with fine silk or cotton. Twisting or kinking of the pedicle must not be sufficient to interfere with the blood supply.

The wound from which the graft has been removed is partially closed with interrupted sutures. The graft and pedicle may be dressed with 3 per cent Xeroform gauze. Slight pressure on the graft is indicated to hold it in contact with the grafted area, but too much pressure will endanger the blood supply.

After ten days the pedicle of the graft can usually be severed. If there is any doubt about its viability, this step should be postponed a few days. A partial section of the pedicle each day for three or four days is often advisable. After the pedicle has been severed the graft is further shaped to fit the defect, and the unused portion is replaced in its old bed. A small Thiersch graft may be advisable to cover the defect completely.

Technique of Grafting Foot and Ankle Defects (Fig. 69)

The method used by Ghormley and Lipscomb is described.

First Stage. A graft of the proper size is outlined on the medial surface of the leg. Parallel incisions are made, and the proposed graft is undercut to produce the desired thickness and leave the ends intact. Bleeding is controlled by pressure or very fine ligatures. The incisions are closed with interrupted sutures of fine silk. A Penrose drain is placed beneath the central portion of the flap, and a pressure dressing is applied. The drain is removed at the end of forty-eight or seventy-two hours, and another pressure dressing is applied.

Second Stage. Ten days after the first-stage operation the stitches are removed, and the flap is raised by blunt dissection. The flap is again sutured, and the wound is treated as in the first stage.

Third Stage. After a second ten days the sutures are removed, and the flap is again raised. A split skin graft removed from the thigh with the Padgett dermatome is sutured into the defect beneath the flap. The flap is again sutured as in the previous stages, but the wound is not drained. A light pressure dressing is applied.

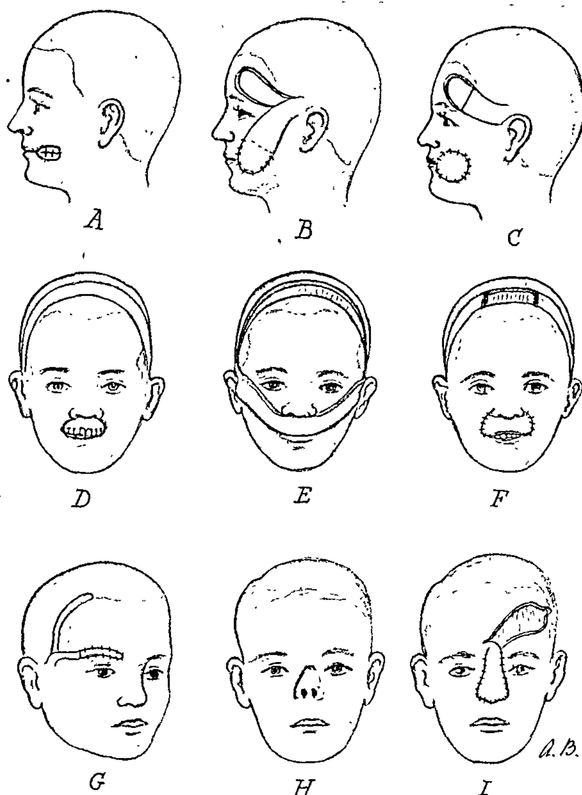


FIGURE 68 *A*, Defect in the cheek to be closed with a pedicled flap from the forehead lined with a skin graft *B*, Transplanted flap sutured into defect in cheek *C*, Unused portion of pedicled flap sutured in its original position. *D*, Double pedicled flap from the scalp used for the formation of a new upper lip *E*, Double pedicled flap, previously raised and lined by Thiersch grafts, in place *F*, Double pedicled flap in place with unused portions returned to original positions in scalp. *G*, Formation of a hairy eyebrow by a pedicled flap from the scalp *H*, Defect of nose to be covered with pedicled flap from the forehead (Indian method) *I*, Pedicled flap sutured over nasal defect. (Redrawn from Babcock's Textbook of Surgery)

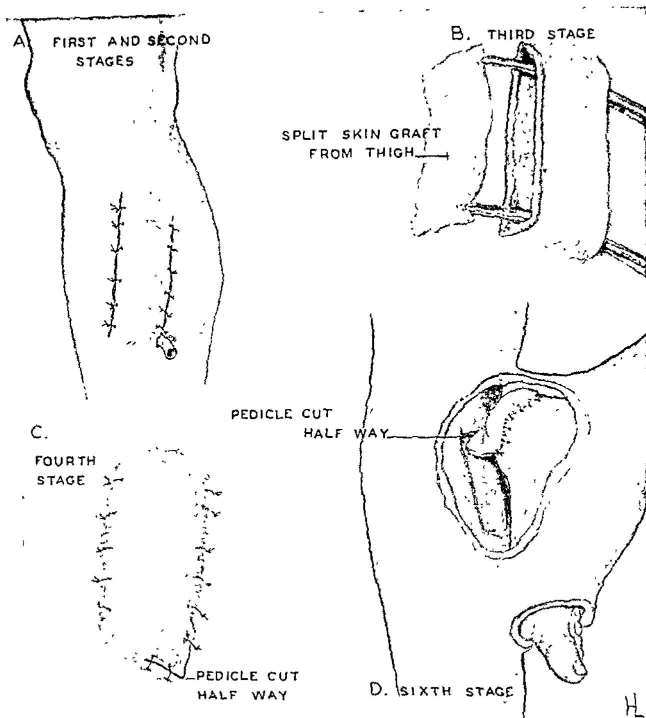


FIGURE 69. Technique of untubed pedicle graft. *A*, Flap has been elevated and sutured in its original position. *B*, Split skin graft from thigh to be sutured *beneath skin flap* *C*, The distal end of the flap has been cut halfway across and sutured. *D*, The distal end of the pedicle has been sutured over the defect on the heel and held in position by *plaster casts*. The proximal end has been cut halfway across, to be sutured in its original position. (Redrawn from Ghormley and Lipscomb: J. Bone & Joint Surg., Vol. 26)

Fourth Stage. Ten days after the third operation the distal end of the flap is clamped to test its circulation. If the circulation in the flap is not embarrassed, the distal end is cut halfway across and closed with silk sutures. At this time, or three or four days later, a plaster cast is applied from the toes to the midthigh on the extremity with the prepared graft, and a short cast is applied from the toes to the knee on the opposite leg. Large windows are cut in the casts over the graft and over the defect to be grafted.

Fifth Stage. About three or four days after completion of the fourth stage all sutures are removed from the flap. If the circulation is adequate, the other half of the distal end of the flap is severed. At this time the split graft is usually healed firmly. After careful preparation of the operative field the defect to be grafted is excised. Bleeding must be controlled. The under side of the free end of the pedicle graft is freshened until normal fat is reached, and the graft is sutured into the prepared defect with interrupted fine silk sutures.

The wound is covered with petrolatum gauze, and a light pressure dressing is applied. The two casts are firmly bound together with plaster bandages and braced for immobility. A window is cut over the defect. During the next twenty-four hours the graft is inspected two or three times, and any necessary adjustments are made. The dressings are changed as required during the next three weeks.

Sixth Stage. At the end of three weeks the graft will usually be attached firmly to its new bed. The proximal end of the graft is cut half across and closed with interrupted silk sutures.

Seventh Stage. The remaining half of the graft pedicle can usually be severed three or four days after the sixth stage. If there is no gross infection, the proximal portion of the graft is trimmed and beveled to fit the uncovered portion of the defect. The graft is sutured in place, and a pressure dressing is applied. The casts may be removed to facilitate the final fitting of the graft. At the end of ten to fourteen days the stitches may be removed, and walking on crutches may be permitted in about three weeks after completion of the operation. If the graft is too thick or ill-fitting, a plastic operation may be done later.

Technique of One-Stage Tubed Pedicle Grafts (Fig. 70)

Shaw and Payne described a single pedicle tubed graft constructed from the lower abdominal wall to repair defects of the hand in a one-stage operation, or to attach the graft to the wrist to be later carried to other parts of the body.

The elongated graft is outlined with its base toward Poupart's ligament and includes the superficial epigastric vessels to ensure good blood supply. Two parallel incisions meeting at a rounded tip of the flap are made the desired length to reach the hand defect without tension. These grafts have varied in length from 5 to 18 cm. and in width from 3 to 7 cm. The flap may be raised superficial to Scarpa's fascia or may include it. Relaxation for closure of the donor defect is obtained by undercutting the wound margins. The wound is closed with a subcuticular suture of stainless steel wire.

By staggering the inferior ends of the parallel incisions the tube-flap may be rotated through an arc of 180 degrees. If the medial incision is shorter, the tube will rotate laterally; and if the lateral incision is shorter, the tube will rotate medially.

The flap is formed into a tube with interrupted sutures and fixed in the recipient defect with fine stainless steel or silk sutures.

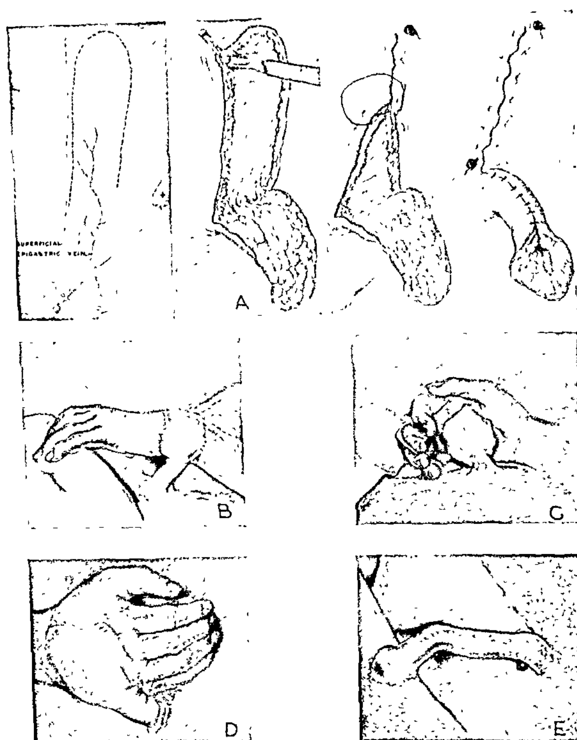


FIGURE 70 Technique of one-stage grafting with single tubed pedicle grafts. *A*, Steps in the construction of a tubed pedicle graft from the lower abdominal wall, including the superficial epigastric veins The margins of the donor wound are undermined and closed with a subcuticular suture of stainless steel wire. *B*, *C*, *D*, *E*, Illustrations showing application of a single tubed pedicle graft (Redrawn from Shaw and Payne. Surg , Gynec & Obst , Vol. 83)

If the original defect is completely covered at the first operation, the tube may be severed in about three weeks. If a portion of the tube is later used to complete the closure of the defect, a longer period is allowed before severing the tube. A longer period of attachment is also advised when the tube end has a small application to the recipient area or when attached to the wrist to be carried to some other portion of the body.

Technique of Delayed Transplantation of Pedicled Graft

A graft of the proper shape and size is outlined, and the skin, with the subcutaneous fat, is raised and resutured in place. All bleeding must be controlled to prevent

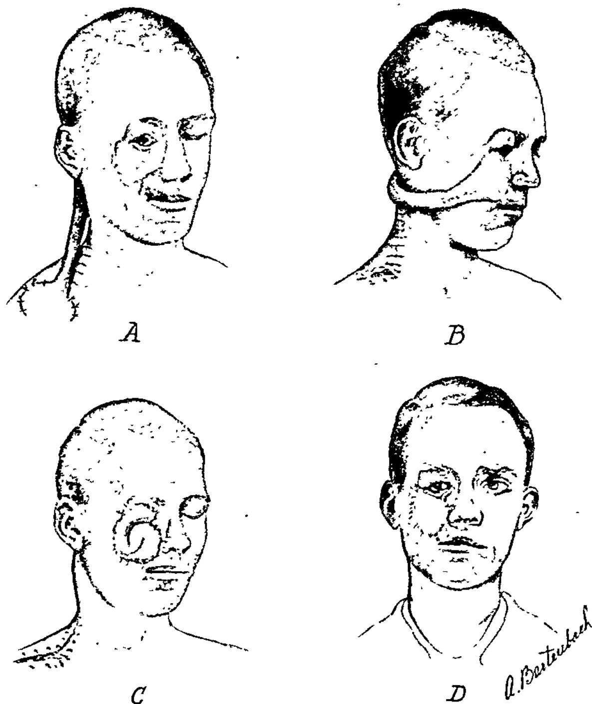


FIGURE 71. Illustrating the use of a tubed graft in the repair of the cheek and eyelids (Redrawn from Davis and Traut Lewis' Practice of Surgery, Vol. V, W. F. Prior Co)

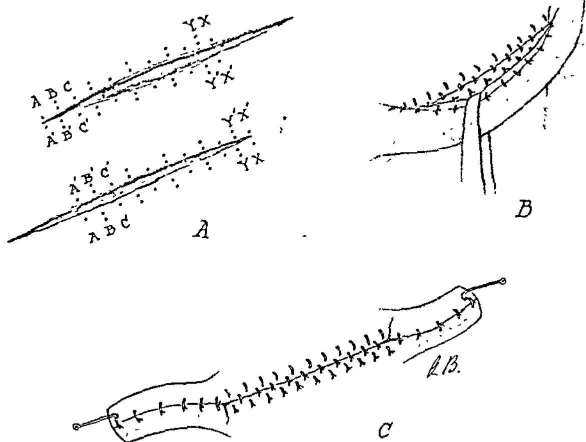


FIGURE 72. A method of tubed flap formation. *A*, Schematic drawing showing staggered parallel incisions and method of closure at sites of perforations. *B*, Tubed graft completed *C*, Tube sectioned to show method of suturing to cover all raw surfaces (Redrawn from Davis and Kitlowski: South. M. J., Vol. 29.)

the formation of clots. Fine silk or cotton sutures are used. The graft may be flat or tubed and have a single or double pedicle (Fig. 71). The double pedicle furnishes a better blood supply.

If a tubed graft is to be used, it should be raised and the margins sutured together. The wound is closed with interrupted sutures and dressed with Xeroform gauze. The plan of making a tubed graft used by Davis and Kitlowski permits complete closure of the wound beneath the graft (Fig. 72).

After seven days to two weeks the graft may be raised and sutured into the prepared wound. If a double pedicled graft is used, one end is cut across and the tube opened and shaped to fit the defect. Partial section of the pedicle each day for several days aids much in estimating the quality of its blood supply.

A dressing of Xeroform or petrolatum gauze with light marine sponge pressure is usually satisfactory. Frequent inspections are necessary to avoid or correct complications.

If the graft is to fill a defect in a cavity, such as the nose or mouth, it must first be lined with a split skin graft or folded upon itself to produce two epithelial surfaces (Fig. 73).

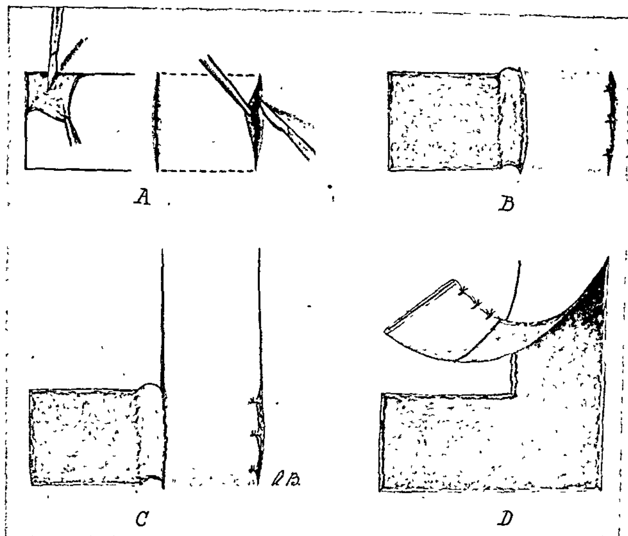


FIGURE 73. Method of lining a skin flap *A*, *B*, Flap is raised and drawn beneath undercut skin. *C*, After healing is complete between *A* and *B* the pedicle of the lined flap is outlined. *D*, The lined portion of the flap with its pedicle has been raised. (Redrawn from Davis and Traut. Lewis' Practice of Surgery, Vol. V, W. F. Prior Co)

After the graft has healed in its new bed, usually within ten to fourteen days, the pedicle may be severed and restored to its original bed.

Technique of Transplanting a Pedicled Flap Including an Artery

A single pedicled graft is outlined and cut so that an artery and its accompanying vein will be included within the graft. An immediate or delayed transfer may be made, depending upon location.

This type of graft is useful in building a new eyebrow from the scalp (Fig. 68). Another example of its use is the transfer of a graft containing the coronary artery from one lip to the other (Chap. 8).

Technique of Making Migrating or Jump Grafts

This type of graft is usually constructed as a tube graft and transferred from one part of the body to another in successive stages. For example, a double pedicled graft may be constructed on the abdominal wall, and when its blood supply is established, it is attached to the hand or wrist to be later transplanted to the face.

A graft may be advanced from one part of the body to another by a process called

"caterpillaring." One end of a tubed graft is advanced at a time in the direction of the long axis of the graft. This method may be useful when torsion is to be avoided.

TECHNIQUE OF Z-INCISION FOR RELIEF OF SCAR CONTRACTURE (FIG. 74)

The lines of incision are outlined. The central line of the Z extends along the most prominent part of the scar. The arms of the Z are made parallel. Two broad triangular flaps are formed. These flaps are undercut, and all binding scar tissue is removed. They are then transposed and sutured in their new positions. A dressing of Xeroform gauze with light pressure produced by a well fitting sterile marine sponge is satisfactory. Stitches are removed as they loosen, from the fourth to the eighth postoperative day. The marine sponge is retained as a dressing until healing is well advanced. Massage is started after healing and should be continued for several months to obtain maximum benefit.

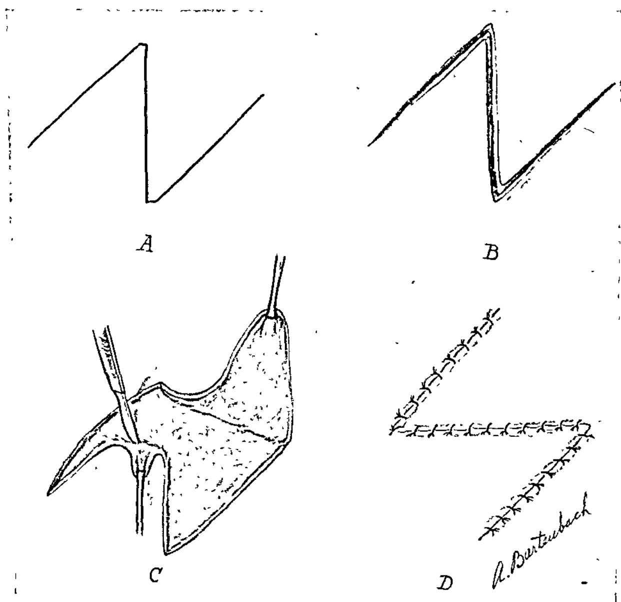


FIGURE 74. Use of the Z-incision for scar contractures. *A*, Outline of Z with sides of equal length and angles of 60 degrees *B*, Incision made as outlined *C*, Flaps thoroughly undercut. *D*, Triangular flaps transposed and sutured. (Redrawn from Davis and Kitlowski: Ann. Surg., Vol. 109.)

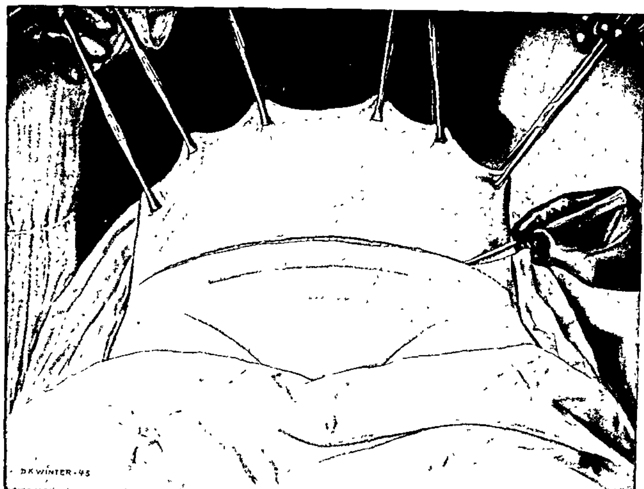


FIGURE 75. Technique of lipectomy. Method of suspending fold of fat with Allis clamps to facilitate the making of clean-cut incisions

TECHNIQUE OF LIPECTOMY

Abdominal lipectomy is indicated in certain obese patients having large umbilical hernias or aprons of fat which overhang the pubic region.

An estimate is made of the size of the skin area with underlying fat which may be removed and permit an accurate wound closure without tension. The fold of fat is held suspended with Allis forceps or tenacula so that the skin incision may be accurately made. An elliptical section of skin with underlying fat is excised down to the abdominal wall fascia. After carefully ligating all bleeding vessels with fine silk or cotton, the wound is irrigated with physiologic sodium chloride solution to remove blood clots and particles of detached fat (Fig. 75).

The wound is closed with two or three rows of interrupted sutures of fine silk or cotton in the fat to obliterate all dead space. The skin is closed with fine silk or cotton placed as vertical mattress sutures to ensure accurate approximation of the skin edges. Drainage is not advised.

TECHNIQUE OF EXCISION OF DECUBITUS ULCER

Before attempting excision and closure of a decubitus ulcer the general nutritional state of the patient must be good and the ulcer must be free from such pathogenic organisms as the *Streptococcus haemolyticus* and *Staphylococcus aureus.*

The ulcer with its peripheral scar is completely excised (Fig. 76). Skin flaps, with their subcutaneous fat, are outlined by making curvilinear incisions on each side from the superior midline of the defect outward above the iliac crests and from the inferior midline outward and downward into the buttocks. Two skin flaps are outlined and raised on each side to fit the shape of the defect. Closure of the defect is effected by rotating the sector flaps toward each other horizontally and sliding them medially until the edges meet.

The margins of the flaps are sutured together with interrupted sutures of silk or cotton.

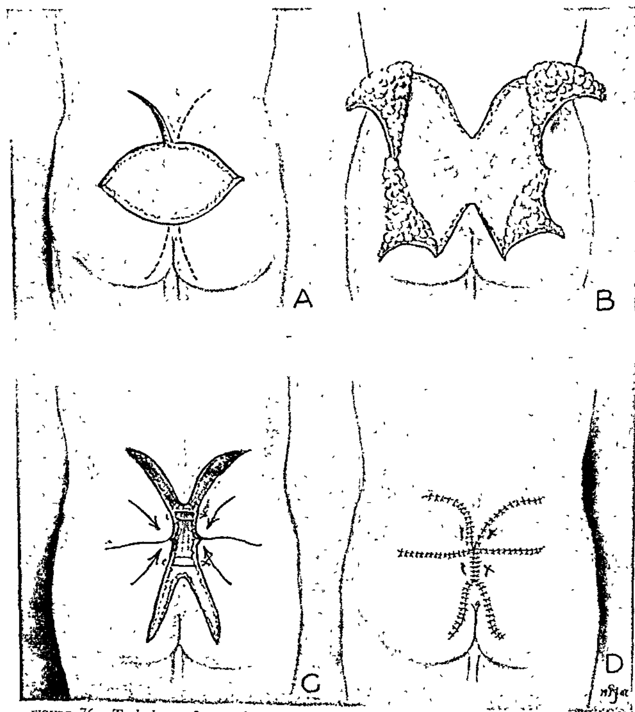


FIGURE 76. Technique of operative treatment for decubitus ulcer *A*, Ulcer has been excised. Locations of curvilinear incisions *B*, Four sector flaps completely raised *C*. Method of approximating sector flaps. D, All flaps sutured covering the ulcer defect. (Redrawn from Croce, Schullinger and Shearer: Ann. Surg., Vol. 123)

A pressure dressing is applied and held in place by an elastic bandage of the Ace type encircling the pelvis.

This operation has been used successfully by Croce, Schullinger and Shearer for the treatment of extensive sacral ulcers in the paraplegic.

TREATMENT OF CARBUNCLE WITH GRIDIRON INCISION

Small carbuncles do not usually require incision or excision. Excision results in prolonged healing with the production of a large scar. Treatment with warm moist packs and the antibiotics is usually sufficient to effect a cure with minimum scarring.

To afford good drainage, promote rapid healing and to prevent extensive scarring in the treatment of large carbuncles, Maes and Heringman recommended a gridiron type of incision (Fig. 77). Multiple parallel incisions are made through the infected area extending to the deep fascia beneath and beyond the leukocyte barrier into normal, viable tissue. These incisions are made from 2 to 3 cm. apart. The bleeding is usually brisk and may be controlled with gauze packing to be removed in

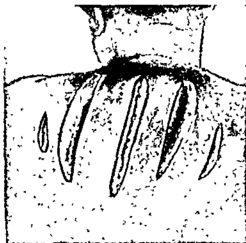


FIGURE 77 Technique of treatment of carbuncle with gridiron incision. Incisions made through infected area to viable tissue. (Redrawn from Maes and Heringman: Tr. West. Surg. Asso)

twenty-four hours. Warm, moist dressings are used as long as purulent drainage persists. Small strips of petrolatum gauze may be used to promote drainage and to prevent too rapid closure of the wounds. Intramuscular injections of penicillin are given to prevent spread of the infection. Careful consideration should be given the general treatment of the patient, particularly if he has diabetes.

PARONYCHIA

Technique of Operation

The operation described by Kanavel is usually recommended. If the infection is early, a simple incision is adequate. If the root of the nail is involved, it becomes separated and acts as a foreign body and prevents drainage from beneath the nail.

Lateral incisions are made upward from the sides of the nail to a level with the sulcus (Fig 78). This avoids injuring the nail bed. The eponychium is pushed back, and the root of the nail is removed with scissors. A thin strip of petrolatum gauze placed beneath the cuticle flap affords adequate drainage.

Simple excision of the root of the nail by cutting across its base with a sharp knife

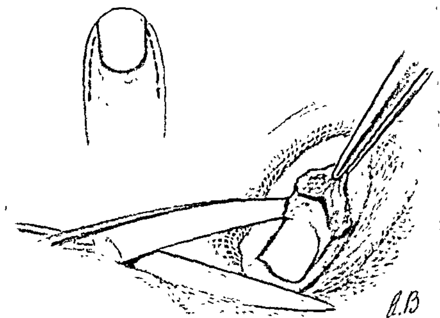


FIGURE 78. Operation for extensive paronychia *A*, Lines of incision. *B*, Flap has been raised, exposing base of nail Loosened base of nail is removed with scissors. (After Kanavel: Infections of the Hand, Lea & Febiger, 1939.)

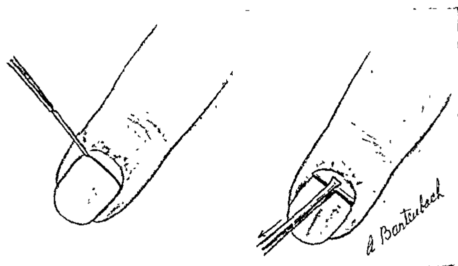


FIGURE 79 Excision of root of nail for suppurative paronychia The nail is cut across with a sharp knife without injuring the nail bed The root of the nail is extracted with a hemostat or Allis clamp.

is often sufficient (Fig. 79). This can usually be done without an anesthetic. The nail bed must not be injured. Exuberant granulations appear at the base of the nail during the healing, but apparently do no harm to the nail bed. Warm moist dressings should be used until all acute infection subsides.

EXCISION OF INGROWN TOENAIL

Technique of Operation (Fig. 80)

An incision is made through the nail and matrix and through the skin over the nail root. A second incision through the fold of skin at the nail margin connects the ends of the primary incision. About one fourth of the nail with its matrix, and the

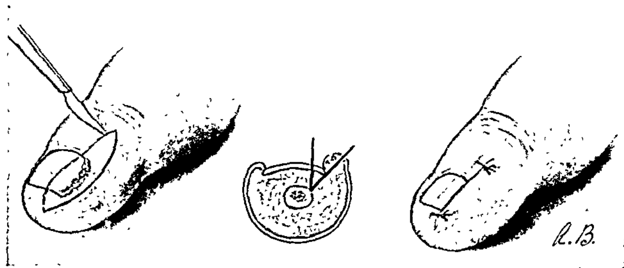


FIGURE 80. Method of excising an ingrown toenail.

skin along the nail margin are removed. If the matrix or root of the nail remains, the nail will re-form. The wound is partially closed with a silk stitch at the base and another beyond the tip of the nail. Healing is usually complete in about three weeks.

INCISION AND DRAINAGE OF FELON

Technique of Operation

A gas anesthetic is usually advisable. An incision is made in the side of the finger to avoid a scar on the palmar surface (Fig. 81). A circular incision around the tip of the finger produces a sensitive scar and is not advised. The incision must be made long *enough to drain the infected area adequately. It is usually necessary to extend the* incision down to the bone. The incision should not be extended proximally beyond the base of the phalanx because of the danger of infecting the flexor tendon sheath.

In late cases there is frequently necrosis of bone. Any loose bone or sloughing tissue should be removed with forceps. A curet or bone-cutting forceps should not be used. Exposed bone may heal if treated conservatively.

Advanced cases may require incision on both sides of the finger to secure ade-

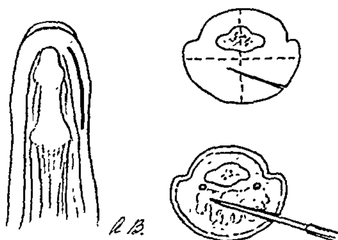


FIGURE 81 Technique of incision and drainage of a felon. (Redrawn from Koch J.A.M.A.)

quate drainage. A small rubber tissue or petrolatum gauze drain is usually sufficient. Warm moist dressings are used until the infection is controlled.

OPERATION FOR WEBBED FINGERS

General Considerations

MacCollum states that the optimum time for operation upon the usual type of webbed fingers is between the sixth and seventh years of age, before the child is old enough to be embarrassed by the deformity. When the fingers are tightly united with or without bony fusion, they are nearly always the same length. When the fingers are of equal length, the operation should be done at an early age, preferably between the ages of two and five years, to permit normal growth.

Dangers and Safeguards

To avoid infection, several thorough scrubbings of the hand with soap and water are advised during the forty-eight hours preceding the operation. The nails are clipped short and cleansed, and any callus in the palm at the base of the fingers is cut away with a razor blade. Much of the success of the operation depends upon the post-operative care as outlined below.

Technique of Operation (MacCollum) (Fig. 82)

General anesthesia is necessary. The palmar and dorsal incisions are first outlined with scratch marks. The incisions will take the form of a letter Y on both the palmar and dorsal surfaces. On the dorsum the incision begins at the tip of the fusion and extends along the fusion line to a point just proximal to the proximal interphalangeal joint. Here the incision extends to the right and left to center directly over the center of the metacarpophalangeal joints of the fingers involved. These incisions outline a V-shaped flap which is carefully raised to avoid injury to its blood supply. On the palmar side the incision extends from the tip of the web to a point just proximal to the proximal interphalangeal joint. The line divides and forms a V-shaped flap smaller in size than the dorsal flap, with a base level no lower than the normal webs on the hand. This flap is carefully freed to its base. The circulation to the flap must not be injured.

The fingers are separated, and the dorsal and palmar flaps are sutured together to form a Z-shaped suture line. No. 000 plain catgut is used for ligatures and subcutaneous sutures when necessary. Ligatures and buried sutures should be reduced to a minimum. Fine silk is used to close the skin. To control bleeding, pressure at the base of the fingers by the first assistant and warm moist packs are advised instead of a tourniquet.

After absolute hemostasis two thick skin grafts are cut from the thigh with a razor, shaped to fit, and sutured under slight tension over the raw surfaces of the fingers with fine silk sutures. Overlapping of the flap is avoided to prevent maceration. After the grafts have been sewed into place irrigation beneath them with physiologic saline solution will dislodge clots and collections of serum.

Strips of gauze soaked in 1:5000 acriflavine are applied directly over the grafts and triangular skin flaps, and a pressure dressing of several layers of gauze is applied.

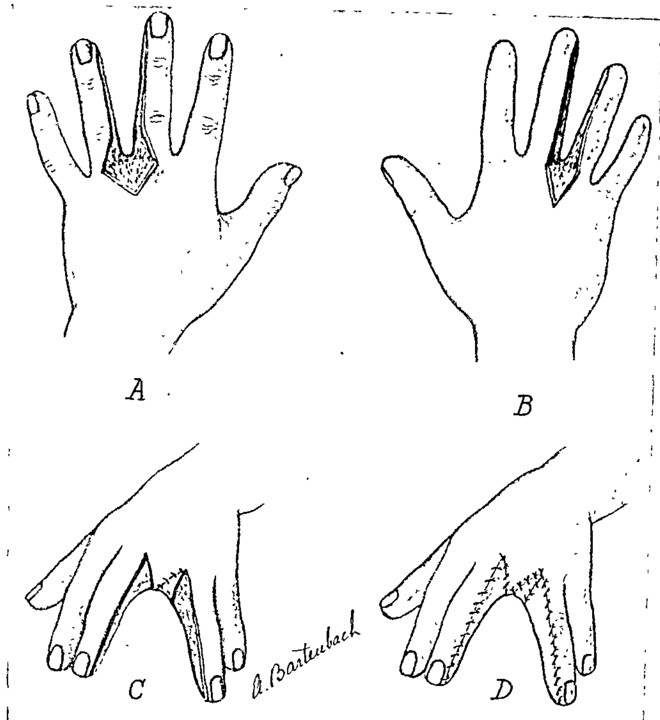


FIGURE 82. *A*, *B*, The fingers have been separated along the line of fusion, leaving a denuded surface on each finger. Triangular palmar and dorsal flaps have been reflected without injury to their blood supply *C*, Triangular flaps sutured through the commissure and to each other. *D*, Divided surfaces covered with split skin grafts. (Redrawn from MacCollum· Surg , Gynec. & Obst)

A well padded Y-shaped board splint is used to hold the fingers separated. It is placed on the dorsal surface and extends upward well beyond the wrist. Elastoplast may be used for fixation of the splint. The finger tips should be visible so that the circulation may be watched. The arm is placed in a sling with the elbow flexed to minimize edema.

Postoperative Care

The dressing is changed on the eighth day after the operation. The hand may be soaked in saline solution to soften the dressings. Silk sutures are removed. The same

type of dressing is applied and changed every two or three days. At the end of fourteen days gentle massage and active and passive motion may be started.

At the end of the third week a more permanent type of splint is fitted to be worn for six months. This splint may be made of aluminum, reinforced with steel, and covered with leather. The prolonged splinting prevents contracture of grafts. During the first three to four months the hand is removed from the splint daily for soaking, massage and exercise. The time of release from the splint is prolonged during the next two months to periods of an hour. Physical therapy is continued for a year. During the last six months the splint is worn only at night.

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CHAPTER 6

Operations upon Muscle, Fascia and Bursa

MUSCLE

PRIMARY tumors arising in muscle tissue are rare. They are treated by simple excision. Suppurative infections are incised and drained. Extensive gas bacillus infection may require the complete excision of a muscle or group of muscles. Complete rupture of a muscle by direct or indirect violence should be repaired immediately by open operation. After some delay following rupture, contracture and fibrosis may develop, and a plastic operation may be necessary.

MUSCLE RUPTURE

Technique of Muscle Suture

An incision is made along the margin of the muscle to avoid adhesions between the repaired muscle and skin. The blood clot usually present is removed, and the fragmented muscle ends are smoothed with knife or scissors. With the muscle relaxed as much as possible, the ends are united with mattress sutures of chromic catgut or silk (Fig. 83). The skin wound is closed without drainage. The part is

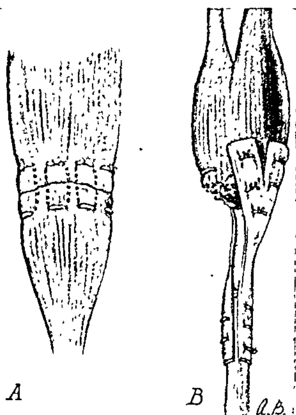


FIGURE 83. Technique of muscle suture. *A*, Ruptured muscle united with mattress sutures. *B*, Repair of ruptured muscle with fascia after contracture and atrophy. (Redrawn from Bunnell: Lewis' Practice of Surgery, Vol. III, W. F. Prior Co.)

splinted with the muscle relaxed for two weeks, followed by gradual exercise until function returns.

If operation has been delayed and the ruptured muscle has healed, the muscle should be freed of scar tissue and mobilized before suture is attempted. The contracture may be so great that approximation of the muscle ends may be impossible. Fascial transplants from the fascia lata are used to bridge the muscle gap (*Fig. 83*).

MUSCLE HERNIA

Technique of Repair of Muscle Hernia

Muscle hernia through its fascial sheath rarely causes symptoms, and operation is not often indicated. In exceptional cases producing symptoms surgical repair is advisable.

An incision parallel with the muscle involved is made over the hernia. The thickened margins of the fascial defect are freed and undercut. To produce relaxation, the defect is enlarged above and below. The fascial edges are overlapped, when possible, and closed with a double row of interrupted silk or cotton sutures. If closure is not possible by this method, a patch of fascia may be taken from the opposite thigh and sutured into the defect, or fascial sutures may be used to bridge the gap.

VOLKMANN'S ISCHEMIC CONTRACTURE

Volkmann's ischemic contracture is caused by tight splints or bandages used for the treatment of fractures of the forearm or about the elbow. Direct injury to the

Neurolysis. Involvement of the nerve trunks in scar tissue with resulting disturbance of sensation, muscle atrophy and trophic changes may be a part of the process of ischemic paralysis. When such a condition exists, a complete freeing of the major nerves in the wrist and forearm or at the elbow is advisable. This may be indicated as part of a tendon operation.

Bone-Shortening Operation. This may be done by resection of the carpal bones or partial resection of the bones of the forearm.

To resect the carpal bones, a midline incision on the dorsum of the wrist parallel with the tendons is satisfactory. The proximal row of bones or all the carpal bones may be removed as found necessary to dorsiflex the hand. Arthrodesis may be produced by removing the articular surface of the remaining bones.

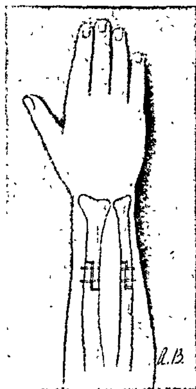


FIGURE 86. Z-plastic resection of both bones of forearm to aid correction of Volkmann's contracture. (Redrawn from Campbell: Operative Orthopedics)

To shorten the forearm bones, incisions are made over the ulna and radius in the lower third. Bones are shortened by a Z-plastic type of operation. The ends are united with bone pegs or screws (Fig. 86).

TORTICOLLIS

The nonspastic type of torticollis may be corrected by myotomy of the sternocleidomastoid muscle. The spastic type may be treated by neurectomy.

Technique of Myotomy

An incision about 6 cm. long is made above and parallel to the clavicle over the sternal and clavicular heads of the muscle. The fascia and platysma muscle are divided, and the muscles are separated from their sheaths. Both muscles are severed near their insertions (Fig. 87). When greater relaxation of the contracted tissues is necessary, the muscle may be divided again through a higher incision.

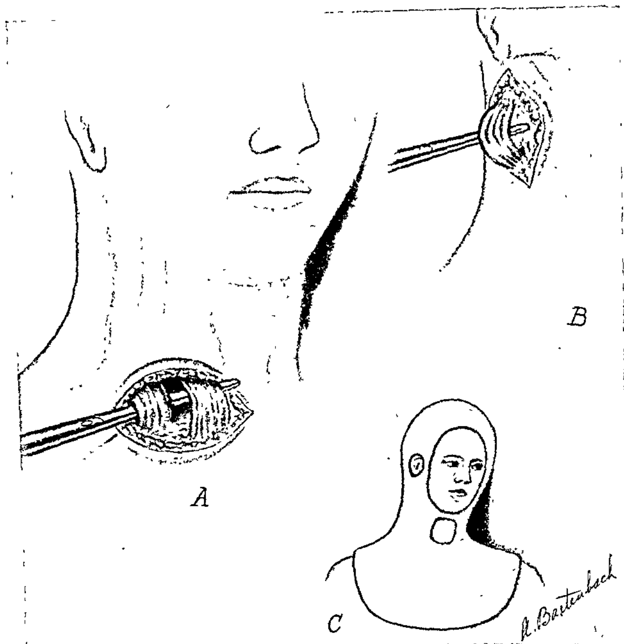


FIGURE 87. Myotomy for torticollis. *A*, Exposure of lower end of sternocleidomastoid muscle for myotomy. *B*, Exposure of upper end of sternocleidomastoid muscle for myotomy—method of Lange. *C*, Cast applied with overcorrection of deformity. (Redrawn from Steindler: Operative Orthopedics)

The platysma and skin are sutured, and a cast is applied to the head and neck with the deformity in an overcorrected position.

FASCIA

Fascial grafting is the most frequent operation upon fascia. Grafts are usually taken from the fascia lata. Autogenous grafts are superior to those taken from another person.

Fascial strips may be used as sutures in the repair of inguinal hernias. Patches of fascia may also be useful in the repair of large ventral hernias and for the closure of defects in the chest wall and dura. Strips of fascia lata may be used in the correction of certain paralytic deformities, to reinforce ligaments, as a substitute for

the crucial ligaments of the knee joint, as a tendon pulley, to reduce deformity in facial paralysis, to correct ptosis of the eyelid, and as pedunculated or free grafts in arthroplasty.

Open or subcutaneous fasciotomy may be indicated for contractures of the hip and knee, and for certain types of sciatic pain.

Technique of Obtaining Fascial Grafts from the Fascia Lata

Strips or sheets of fascia may be removed through a long incision in the outer surface of the thigh (Fig. 88). Muscle hernia is less likely to be troublesome if the fascia is removed from the lower half of the thigh. Defects in the fascia lata made by removing strips for sutures may be closed or bridged with catgut or silk if they are not too wide.

To avoid a long incision, a fascial stripper such as that designed by Masson may be used to remove fascial sutures (Fig. 89).

DUPUYTREN'S CONTRACTURE

Conservative treatment is rarely of much value. If the process is very early, a night splint may be worn with the fingers in hyperextension. Subcutaneous fasciotomy has a limited application, but may be of value in selected cases. The radical removal of all involved palmar fascia with or without skin grafting is usually the procedure of choice.

Dangers and Safeguards

Careful preoperative local preparation is necessary to prevent infection. Longitudinal palmar incisions should not be made when they can be avoided. Such incisions cause postoperative flexion contractures. Transverse incisions in the palmar creases are preferable. If the skin of the palm is extensively involved in the palmar contracture, it may be insufficient to cover the palm after removal of the scarred fascia. If such a condition exists, a skin graft or pedicled graft is necessary. Injury to the nerves, vessels and tendons must be avoided. The nerves lie directly beneath the palmar fascia. Adequate splinting and physical therapy following operation are necessary for success.

Technique of Operation

A general anesthetic is advised. The use of a tourniquet to produce a bloodless field is necessary for careful dissection and identification of structures.

The skin incisions recommended by Davis and Finesilver are usually adequate (Fig. 90). If the skin is too much involved, Bunnell advises a tubular pedicled graft from the skin of the abdomen to cover the palmar defect, after excising all involved skin and contracted palmar fascia with its digital prolongations (Fig. 91). Whole-thickness skin grafts may also be used.

The skin of the palm is separated from the underlying contracted fascia by sharp dissection All involved fascia is cut away. The digital extensions of the fascia must be removed. Short transverse incisions at the bases of the fingers may be useful. These incisions must not sever the vessels and nerves to the fingers.

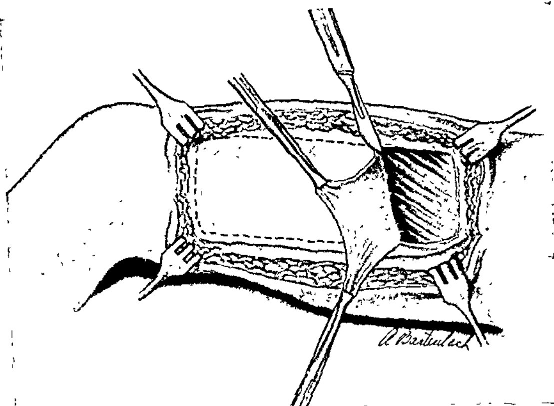


FIGURE 88. Technique of excision of a large patch of fascia from the fascia lata.

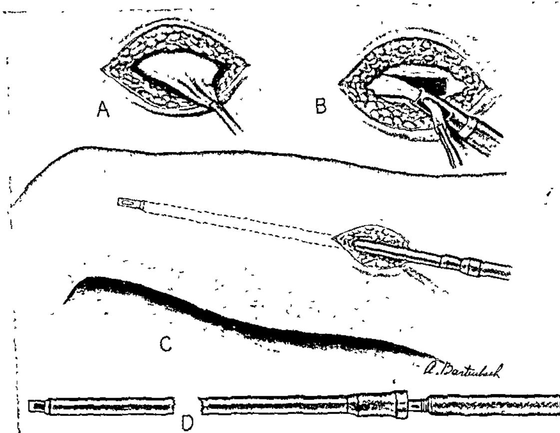


FIGURE 89 Masson instrument for cutting strips of fascia lata. *A*, *B*, Fascia cut and drawn through opening in end of stripping instrument. *C*, Stripping instrument passed along fascia through small incision in outer skin of thigh. *D*, Details of stripper, showing cutting edge at opening in end. (Redrawn from Masson. Virginia M. Monthly.)

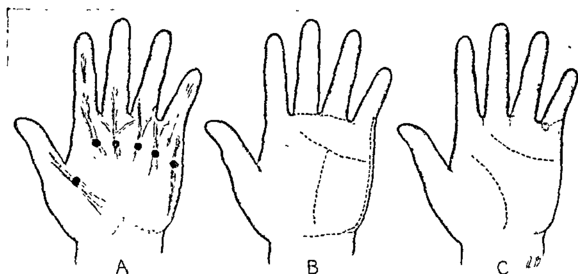


FIGURE 90. *A*, Diagram showing the types of abnormal fascial bands that may be found in Dupuytren's contracture. The positions of the initial lesions over the heads of the metacarpal bones and opposite the flexor lines are indicated by the black spots *B*, *C*, Skin incisions which may be used to remove the palmar fascia in Dupuytren's contracture. (Redrawn from Davis and Finesilver: Arch. Surg.)

FIGURE 91 Pedicled graft from abdominal wall to cover palmar defect after excision of fascia to correct Dupuytren's contracture (Redrawn from Bunnell: Lewis' Practice of Surgery, Vol III, W. F. Prior Co)

After removal of the tourniquet and careful attention to hemostasis, the skin is closed with silk. The fingers should be fully extended or slightly hyperextended and held by a splint which extends upward beyond the wrist. Slight motion of the fingers is started in about ten days. The splint should be worn for another two weeks with daily physical therapy. A night splint for several weeks will aid in preventing a recurrence.

Secondary operations are not infrequently advisable to correct contractures. Stiffened joints or infections may make amputation desirable in some cases.

BURSA

The bursae which not uncommonly require surgical treatment are the calcaneal, prepatellar, infrapatellar, semimembranosus, gastrocnemius, trochanteric, ileopectineal, ischiogluteal (weaver's bottom), subdeltoid, olecranon (miner's elbow) and radiohumeral (tennis elbow).

Operation is seldom indicated for acute bursitis unless suppuration develops. Excellent results have been reported from the injection of cortisone or hydrocortisone into acutely inflamed bursae. Aspiration will hasten recovery if the bursa is filled with fluid. Incision and drainage is advisable if the bursa contains pus. Excision is usually required for recurrent or chronic bursitis.

Technique of Incision and Drainage of Suppurative Bursitis

The incision should be so placed that the resulting scar will receive a minimum of friction and pressure. When bursae are deeply located, the overlying structures must be carefully identified and protected as the dissection proceeds. Careful curettage may be advisable in some cases. Drainage with soft rubber tissue or petrolatum gauze is usually sufficient. Rest and warm moist dressings are recommended until the infection subsides.

Technique of Excision of Bursae

As for incision and drainage, the incision used for excising a bursa should be placed so that the resulting scar will be protected as much as possible from friction and pressure. Removal of the thickened bursal sac is accomplished by blunt and sharp dissection. When a part of the sac is inaccessible or removal entails danger to important structures, the curet may be used. If a bursa communicates with a joint, its margins should be closed without drainage Loose packing with gauze will ensure destruction of the bursal wall when a portion is not removed. Splinting is advisable for a few days.

Technique of Aspiration and Irrigation of Acute Subdeltoid (Subacromial) Bursitis (Fig. 92)

Weeks and Delprat observed that simple puncture of an acute subdeltoid bursitis would relieve the severe pain. Patterson and Darrach report excellent results with aspiration and irrigation.

Two 18-gauge needles and a 20-cc. syringe are used. The skin is anesthetized with a hypodermic needle over the point of maximum tenderness and at a point 1

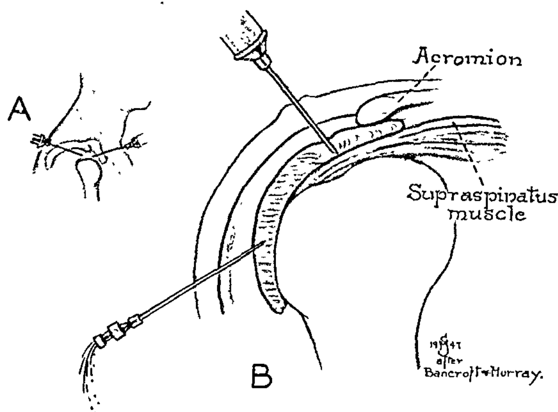


FIGURE 92. Patterson and Darrach technique of aspiration and irrigation for acute subdeltoid bursitis *A*, Points of needle insertion. *B*, Irrigation of bursa with physiologic sodium chloride solution. (Redrawn from Bancroft and Murray. Surgical Treatment of the Motor-Skeletal System, J. B. Lippincott Company)

cm. posterior to the greater tuberosity on a level with its superior facet. One of the large needles is introduced into the bursa and pointed upward beneath the acromion process. When the needle enters the bursa, cloudy fluid may be found under some tension. The second needle is inserted into the bursa just posterior to the greater tuberosity about 1.5 below the acromioclavicular joint. When the needle touches the bone, it is withdrawn about 2 mm. and pointed in the direction of the first needle. A small quantity of 1 per cent procaine is injected into the bursa through each needle.

The bursa is thoroughly irrigated with physiologic sodium chloride solution. All exudate and calcium crystals should be washed out before the irrigation is discontinued.

After the irrigation the arm is carried in a sling. Within four to six days the arm can usually be used without pain.

Technique of Operation for Subdeltoid (Subacromial) Bursitis (Codman)

A general anesthetic is advised. An incision is made from the tip of the acromion process downward a distance of 8 cm. over and parallel to the anterior margin of the deltoid muscle. The bursa lies between the deltoid muscle and the shoulder joint capsule and extends upward beneath the acromion process. It is exposed by separating the fibers of the deltoid muscle by blunt dissection. By abducting and rotating the arm the extent of the bursa can usually be determined. The entire bursa, or as much of it as possible, is excised by sharp and blunt dissection. The tendon of the supra-

spinatus muscle, which lies beneath the bursa, is inspected. Any calcareous deposits present are usually found in this tendon. Such deposits should be removed after incising the tendon longitudinally. A curet may be used. If the tendon has been ruptured, it should be repaired with silk sutures.

The wound in the muscle and skin is closed, and the arm is placed in abduction at 90 degrees and external rotation. This may be done with a plaster spica, a shoulder splint or by tying the wrist to the head of the bed. Any inflammatory reaction or excessive swelling should be treated with warm moist packs. After ten days active motion and physical therapy are begun. This operation produces good results in a high percentage of cases.

Technique of Operation for "Tennis Elbow" (Osgood)

This condition may be due to a radiohumeral bursitis. An incision 5 cm. long is made over the radiohumeral joint, extending from above the external epicondyle downward over the head of the radius. The conjoined tendon formed by attachments of the extensor muscles is split, and, when present, the small bursa beneath is excised. If a definite bursa cannot be demonstrated, the tissue between the tendon and epicondyle is excised, or the conjoined tendon is divided transversely as recommended by Hohmann.

Technique of Excision of Baker's Cyst

A Baker's cyst is connected with the knee joint and probably arises by distention of one of the bursae near the joint and extends into the popliteal space.

A tourniquet is usually advisable. A transverse incision is made over the cyst and extended upward from one end and downward from the other to give adequate exposure. The cyst is usually encountered just beneath the popliteal fascia. By blunt and sharp dissection the cyst is followed downward to its narrow neck which connects with the joint. Good exposure is obtained by the use of small right-angled retractors. The pedicle near the joint is divided and closed with interrupted fine silk sutures, or transfixed and ligated. The fascia and skin are closed with fine silk. The knee is splinted for a few days, after which active exercise may be permitted.

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CHAPTER 7

Tendons and Tendon Sheaths

MAJOR HAND INFECTIONS

General Considerations

Present concepts in the management of hand infections and injuries date back to the classic work of Kanavel and his publication of *Infections of the Hand*, first appearing in 1907. This and subsequent work along with contributions by Koch, Mason and Bunnell have emphasized the tremendous economic and functional value of the hand and established surgical management based on fundamental anatomic and physiologic principles. Fortunately the use of antibiotics has decreased the incidence of fulminant, spreading hand infections; however, the basic principles of management have remained the same.

Surgical operations are indicated for suppurative infections of the tendon sheaths and fascial spaces of the hand and forearm. Surgery of the fascial spaces is here included with tendon surgery because infection arising in the tendon sheaths commonly spreads to the fascial spaces.

The tendon sheaths of the palm and the two major fascial spaces are shown in Figure 93. On the back of the hand and over the wrist beneath the dorsal carpal ligament are six compartments varying in length from 4 to 6 cm. Through these compartments pass the extensor tendons of the fingers and wrist.

There are five major fascial spaces in the hand in which pus may accumulate.

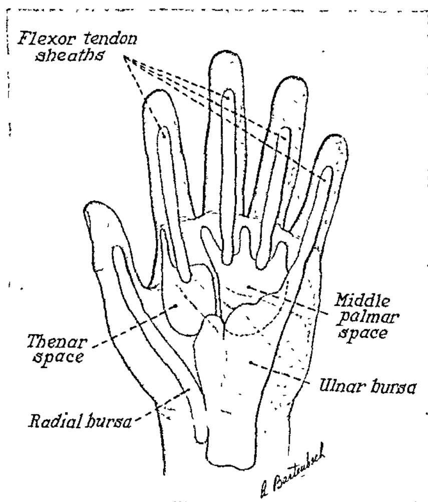


FIGURE 93. Diagram showing flexor tendon sheaths, bursae and fascial spaces of the hand. (Redrawn from Kanavel.)

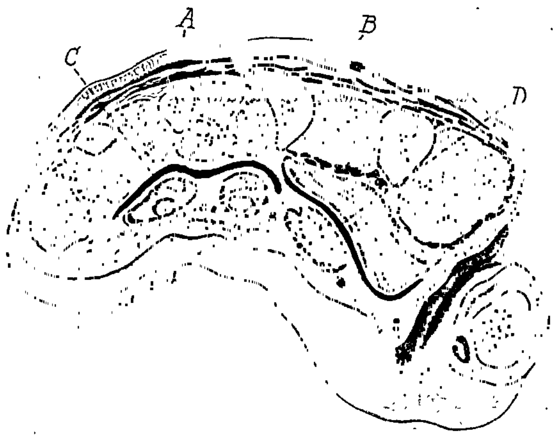


FIGURE 94. Cross section of hand 3 cm. proximal to metacarpophalangeal joints. *A*, Dorsal subcutaneous space. *B*, Dorsal subaponeurotic space. *C*, Middle palmar space. *D*, Thenar space. (Redrawn from Kanavel.)

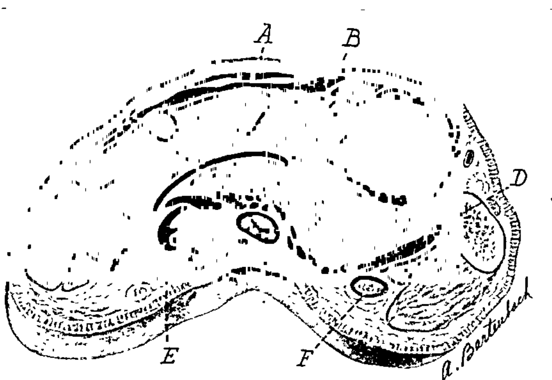


FIGURE 95 Cross section through distal part of thenar area *A*, Dorsal subcutaneous space. *B*, Dorsal subaponeurotic space *C*, Middle palmar space *D*, Thenar space *E*, Ulnar bursa. *F*, Radial bursa (Redrawn from Kanavel)

They are the dorsal subcutaneous space, the dorsal subaponeurotic space, the thenar space, the middle palmar space and the web spaces between the bases of the fingers (Figs. 94, 95).

There is a large fascial space in the lower forearm between the flexor profundus group of muscles and pronator quadratus muscle—the retroflexor space. Into this space infections may extend from the palmar tendon sheaths or from the middle palmar space.

Dangers and Safeguards

Kanavel states that "the hand with its complicated network of nerves, blood vessels, and tendons is not the proper field for the surgeon whose motto is 'Get in and get out,' and who is completely satisfied if he finds an accumulation of pus."

The three severe *types* of hand infection are lymphangitis, tenosynovitis and fascial space infection. These three types are usually distinct processes, although they may be combined. The treatment of each type is essentially different, and any misdirected surgery may lead to irreparable harm. To incise a part for lymphangitis before there is present an accumulation of pus may spread infection. Infection extending from tendon sheath to tendon sheath, from tendon sheath to fascial space, or vice versa, may result from faulty diagnosis or careless surgery. The use of antibiotics must be considered only a part of the management of hand infection to be used in conjunction with the other basic principles of management.

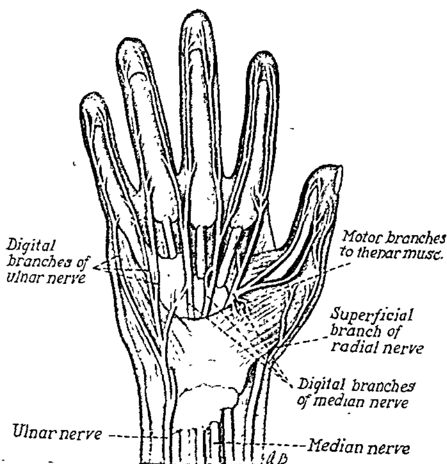


FIGURE 96 Dissection showing the locations of the major nerves and their branches in the wrist and hand. (After Spalteholz)

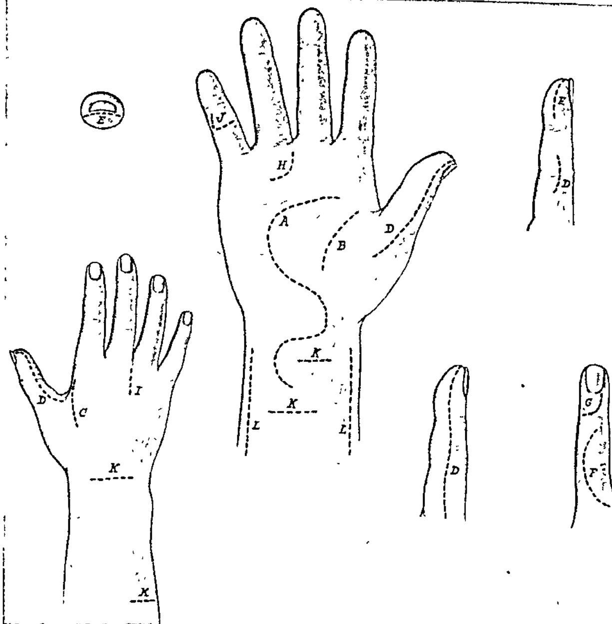


FIGURE 97 A chart of advisable or correct incisions in the hand which will afford access and not cause disability *A*, Incision for approach into palm for drainage of middle palmar space. It parallels the flexion creases, except in the immovable part or heel of the hand, allows wide opening by a triangular flap, and can be prolonged so as to separate without severance the branches of the median nerve from those of the ulnar nerve It may then be extended up through the annular ligament at its ulnar edge and up the forearm, as shown. It crosses the flexion crease in the wrist in a curve so as to avoid subsequent flexion contracture *B*, Incision for draining thenar space. It parallels the thenar crease, must not sever the thenar motor nerve, and must leave pedicles sufficiently wide to nourish area of the skin between it and incision for middle palmar space abscess *C*, Incision for part of thenar space dorsal to adductor muscles of thumb It should be radial to the first interosseous muscle and stop short of cutting the radial artery as it passes through the first cleft *D*, Midlateral incisions in fingers and thumb which avoid volar nerves and vessels and do not produce flexion contractures If made intermittently opposite the joints, the annular ligaments or pulleys which are opposite the centers of phalanges will be spared *E*, Incision for draining pulp abscess One should cut across lateral fat columns, be posterior to tactile surface, and not cause tenosynovitis by nicking the sheath of the flexor tendon *F*, Flap incision for approach to extensor tendon in finger, so that the incision will be remote from the tendon. *G*, Incision for approach to insertion of extensor tendon *H*, Palmar approach to collar-button abscess to give open drainage Avoid cutting nerve to finger *I*, Dorsal approach to posterior part of collar-button abscess It does not overlie the joint or tendon. *J*, Flap incision for subcutaneous abscess One arm should be median to nerve; the other blocks the upward progress of the infection *K*, Incisions in forearm for reaching tendons should parallel the fine wrinkling of the skin to be inconspicuous eventually and to avoid keloid formation. *L*, Incisions for drainage of quadrilateral space in forearm Entrance should be just anterior to bones and anterior to the radial nerve and posterior to the dorsal branch of the ulnar nerve. (Redrawn from Bunnell; J. Bone & Joint Surg , Vol 14.)

Early diagnosis and drainage of pus accumulations are imperative to avoid extension of infection with its destruction of structures which will result in permanent disability. The disabling *complications* which may result from hand infections are destruction of tendons and tendon sheaths, suppurative arthritis, osteomyelitis, secondary hemorrhage, extensive scarring of soft tissues and persistent edema.

Careful surgery of hand infections demands *general anesthesia* and the use of a *tourniquet.* The major nerves and blood vessels must not be injured by incisions. By using a tourniquet and careful dissection an accumulation of pus may better be identified and the vessels and nerves visualized and protected (Fig. 96). *Adequate incisions* with drainage of all infected recesses, minimum injury to important structures, and

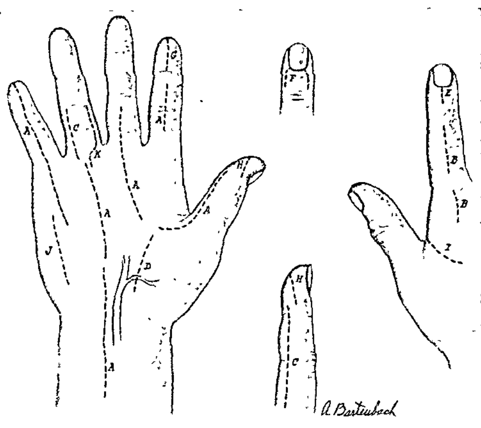


FIGURE 98 A chart of pernicious or incorrect incisions in the hand, any of which will do harm. *A*, Median longitudinal incisions which cross flexion creases at right angles and result in flexion contractures These are prevalent but pernicious *B*, Median incision on dorsum of finger which later leaves a scar that contracts and hinders flexion of the finger When present, it is impossible to fashion a proper skin flap under which to repair the extensor tendon *C*, Anterolateral incision in finger which is directly over and endangers the vessels and nerve It is the usual one pictured for draining tendon sheaths, but should instead be midlateral. *D*, Incision which thoughtlessly severs the motor thenar nerve and so robs the thumb of the power of opposition. *E*, Median longitudinal incision through matrix will produce a ridged nail. *F*, Incisions for paronychia often pictured, but erroneous, since they do not drain the bottoms of the clefts formed by the borders of the base of the nail which curve strongly forward *G*, Median longitudinal incision in pulp for drainage of a felon. It will not drain, since, owing to cleavage planes, the pus progresses in spite of it and points dorsilaterally. Also, the scar resulting is in the tactile surface. *H*, Alligator-mouth incision wron[illegible]
across a web injures the web,
of thumb *J*, Incision often [illegible]
however, converge sharply in palm to pass between the ridge of the trapezium and the uniciform process of the unciform bone *K*, Incision continuous from finger to palm severs nerve, thus rendering half of finger permanently anesthetic. (Redrawn from Bunnell: J. Bone & Joint Surg., Vol. 14)

thorough after-treatment are essential to the success of operations for infection of tendon sheaths and fascial spaces.

The injudicious use of incisions may ruin what would otherwise be a successful operation with a good functional result. Careful diagnosis and placing of incisions where they will drain the infection adequately and do the least harm by the formation of scar tissue are essential to success. A study of the incisions used by Bunnell is recommended (Figs. 97, 98).

Incisions in the proper place and of adequate size are more important than *drainage material*. Drains left in a wound longer than twenty-four to forty-eight hours are usually unnecessary and may be detrimental by preventing drainage. Rubber tubes cause tissue necrosis and should never be used. Adequate drainage can generally be secured with rubber tissue or by the use of gauze saturated with petrolatum. Wounds should be carefully watched and necrotic tissue removed with forceps.

After operation, *rest* is essential. The hand should be placed in a position of greatest function with a cock-up splint. *Hot moist dressings* of saturated boric acid solution are useful. Heat and drainage are more important than antiseptics.

Voluminous moist dressings extending to the shoulder may be alternated with immersion in hot water and the application of dry heat. The general condition of the patient must receive proper attention. Fluids and blood transfusions are given when indicated. Physical therapy should be started as soon as the danger of spreading infection has passed.

Technique of Tendon Sheath Drainage

Elevate the arm and apply a tourniquet. An incision is made in the lateral aspect of the finger to avoid the vessels and nerves (Fig. 99). If the index finger is involved, the incision is most readily made on the radial side.

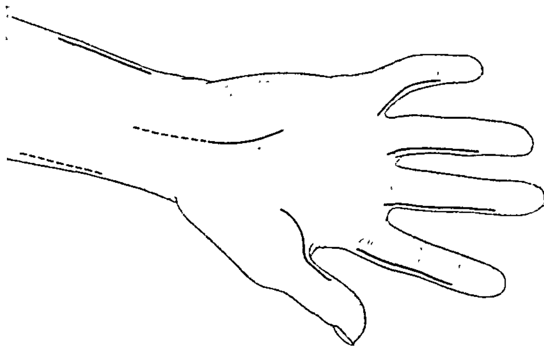


FIGURE 99 Incisions for draining infected tendon sheaths Dotted lines indicate incision that should be used in exceptional cases (Redrawn from Kanavel)

If the infection is extensive, the incision is extended from the distal interphalangeal joint proximally to the finger web. Nothing is gained by incisions on both sides of the finger, and through-and-through drainage is not necessary.

Incisions should be made carefully in a bloodless field so that the structures may be easily identified. The vessels and nerves must be retracted and preserved. As the incision deepens, the edematous tendon sheath can be identified. If the sheath is distended with pus, it should be opened widely. Drainage of a tendon sheath through a small wound is seldom adequate.

The tendons should be inspected and removed if necrotic. A necrotic tendon will not heal and will act as a foreign body and prevent healing until removed or extruded.

The middle and ring fingers may be incised on either side. It is preferable to incise the fifth finger on the radial side, where the incision will be in line with the middle palmar space, to which the infection frequently extends.

Rubber tissue or petrolatum gauze drains are used. Such drains should be removed in twenty-four to forty-eight hours. If there is persistent oozing of blood, the edges of the wound may be packed apart with petrolatum gauze. Splint the hand in the cock-up position.

Technique of Incision and Drainage of Tendon Sheath of Fifth Finger and Ulnar Bursa

The finger is incised as described above. The tendon sheath may rarely be separated from the bursa, and infection will not extend into the latter. To avoid introducing infection, it is therefore important to be sure that infection exists in the bursa before making an incision. Careful exploration with a groove director may aid in determining the extent of the infection.

To drain the ulnar bursa, an incision is made from the distal flexion crease of the palm to the base of the palm on the radial side of the hypothenar eminence (Fig. 100).

The digital branches of the ulnar nerve to the fourth and fifth fingers cross the bursa 2 cm. proximal to the fifth metacarpophalangeal joint. These nerves must be visualized and retracted toward the ulnar side out of danger. A groove director inserted in the bursa will aid in determining the extent of the incision. If the infection has spread into the wrist, forearm pressure above will force pus from the wound. Incision of the forearm space is then indicated.

Technique of Incision and Drainage of the Major Forearm Space

An incision 5 to 10 cm. long is made over the lateral flexor surface of the lower end of the ulna. The incision is carried to the bone, and the space is opened by thrusting an artery clamp beneath the muscles. The fascia is incised the length of the skin incision A liberal incision is advisable. The ulnar artery is avoided.

If the infection has spread far up the forearm, a second incision is made midway between the wrist and elbow on the ulnar side and extended through muscle planes to the forearm space. Through this incision there is danger of injuring the ulnar artery.

In extensive infections radial incisions may be advisable, but are usually not necessary for adequate drainage. When a radial incision is to be made, its location is

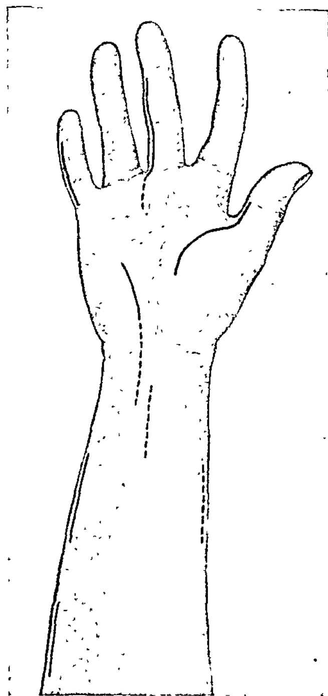


FIGURE 100. Locations for various types of incisions made for infections of the tendon sheaths and their extensions into the forearm. The dotted lines represent incisions to be made only under exceptional circumstances. (Redrawn from Kanavel)

marked by an artery clamp extended across the forearm space from the ulnar side until its point protrudes beneath the skin on the radial side. The radial artery is avoided by passing the artery clamp directly against the flexor surface of the radius dorsal to the artery.

It may be necessary to incise the transverse carpal ligament, *if infection extends* upward in the ulnar bursa, to prevent pressure necrosis of the tendons and median nerve. This is done by extending the ulnar bursa incision upward into the wrist (Figs. 99, 100).

Through-and-through drainage of the forearm is not advised, since it is likely to result in necrosis of tissues and increased scarring. Rubber tissue or petrolatum gauze may be used for drainage or to control bleeding, but should be removed in twenty-four to forty-eight hours.

Technique of Incision and Drainage of the Radial Bursa and Tendon Sheath of the Flexor Pollicis Longus

An incision is made along the ulnar side of the thumb. The digital nerve must be identified and retracted out of danger. After the tendon sheath has been exposed the incision is extended toward the base of the thumb, avoiding digital nerves and the nerve to the thenar muscles (Figs. 99, 100).

The upper end of the radial bursa is usually drained by the method used for drainage of the upper end of the ulnar bursa. An incision is made lateral to the flexor surface of the ulna just above its lower end. Since the radial and ulnar bursae usually communicate, drainage in this manner is effective. Occasionally a radial incision should be made.

In long-neglected cases of extensive infection, drainage may be advisable through the flexor surface of the forearm. The upper part of the transverse carpal ligament may be cut to free the tendons and median nerve.

Technique of Incision and Drainage of the Middle Palmar Space

An incision is made in or parallel to the distal flexion crease of the palm over the swelling (Fig. 97). The digital nerves and vessels are identified and protected in a bloodless field. The incision is extended to permit adequate drainage. A petrolatum gauze pack is inserted between the skin margins, leaving space for drainage.

The dorsum of the hand is usually swollen. This is not an indication for through-and-through drainage, which does more harm than good by spreading infection. Healing will usually follow promptly after adequate palmar drainage and after treatment with warm moist packs and intermittent soakings.

If infection in the dorsal subaponeurotic space develops and is connected with the palmar space after crushing injuries, it should be drained through an incision made parallel to and between the dorsal tendons. Through-and-through drainage from palm to dorsum of the hand is usually not indicated and, when used, may increase the likelihood of the development of osteomyelitis and delay healing.

Technique of Incision and Drainage of the Thenar Space (Fig. 97)

This space is adequately drained by a dorsal incision to avoid a scar in the palm. The incision is made dorsal to the thumb-index finger web on a line between the distal ends of the metacarpal bones of the thumb and index finger. The adductor muscle and index finger tendons are identified and protected.

If there is a combined involvement of the middle palmar and thenar spaces, both can usually be drained through the dorsal thenar space incision. To enter the palmar space, a forceps is passed across the flexor surfaces of the second and third metacarpals beneath the tendons in the palm. The septum dividing the two spaces is ruptured, and rubber tissue drainage is inserted.

Technique of Incision and Drainage of the Subaponeurotic Space

Infections in this space are usually drained through incisions made proximal to the finger webs parallel to and between the tendons (Fig. 97). When the infection is extensive, involving the entire space, it may be safely and adequately drained through

incisions along the radial side of the second metacarpal bone and ulnar side of the fifth metacarpal bone.

Technique of Operation for Tuberculous Tenosynovitis (Fig. 101)

Complete surgical removal of all diseased tissue about the tendons is indicated. This is frequently a time-consuming and tedious procedure. General anesthesia and a tourniquet are advised. A bloodless field is necessary for careful dissection and for avoidance of injury to important structures.

Midline incisions parallel to tendons or, when practicable for small areas of *involvement, transverse flexion crease incisions are used. The nerves and blood vessels* are identified and protected from injury.

All tuberculous tissue is removed. Each tendon is carefully stripped of diseased

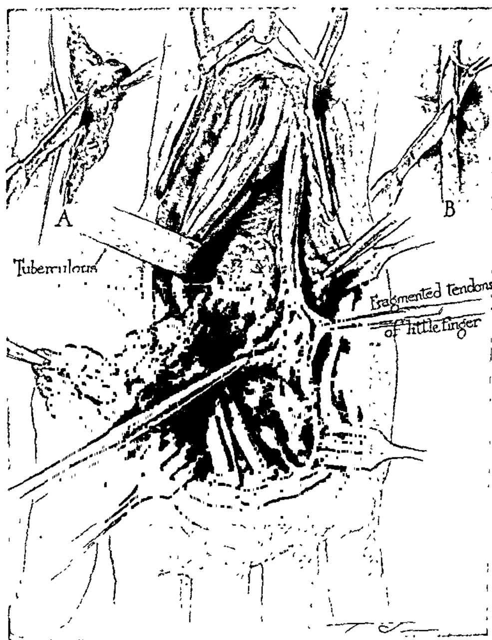


FIGURE 101. Details of operative treatment of tuberculous tenosynovitis. After the median nerve has been carefully retracted, each tendon is taken in turn as in *A* and the tuberculous tissue removed. Great care must be exercised to remove the visceral layer of the sheath as in *B* (Kanavel Surg., *Gynec. & Obs*, Vol 37 By permission of Surgery, Gynecology and Obstetrics.)

tissue. If the tendons are diseased beyond repair, they should be excised and repaired by methods of suture and tendon grafting described elsewhere.

The wound is closed without drainage. Active and passive motion is gradually begun as soon as the pain of operation subsides.

OPERATIONS UPON TENDONS AND TENDON SHEATHS

Dangers and Safeguards

Operations upon tendons require *careful technique.* Infection will usually limit or destroy the function of a tendon, or a section may be lost by necrosis. The mechanical handling of a tendon is important. Crushing, scraping or drying of the tendon promotes the formation of scar tissue. This is also true of blood clots. The technique should be not only aseptic, but also, as much as possible, atraumatic. A blood-pressure band tourniquet should be used. To prevent tissue changes, the tourniquet should be released within an hour. If the operation is prolonged, the tissues should be frequently moistened with physiologic sodium chloride solution. Excessive sponging is to be avoided. Before closing the wound, all bleeding points must be controlled with fine catgut or silk ligatures.

Skin incisions should not be made directly over the tendon to be operated upon when they can be avoided. If the skin is scarred in the region of the operation, the scar tissue should be excised and the area covered with new skin by the use of a pedicled graft before the tendon repair is attempted. The repaired tendon should be surrounded by healthy pliable tissue and should have a good blood and nerve supply. Drainage increases scar tissue and should not be used.

Splinting is necessary to protect tendon sutures. When the flexor tendons at the wrist are repaired, the wrist is splinted in flexion, but the fingers are left free for movement. Extensor tendons require splinting to balance the strong pull of the flexor tendons. Bunnell states that functional activity during the first fifteen days after tendon suture is apparently detrimental to the gliding movement ultimately to be obtained. It therefore seems best to forbid exercise for fifteen to twenty-one days and then allow restricted exercises for a week before beginning more strenuous exercise. Maximum function may not be obtained for several months or a year.

Physical therapy should be used before operation on old cases to restore as much function as possible. If bone operation is necessary, it should be done first. After an operation physical therapy is essential to obtain maximum results.

PRIMARY TENDON REPAIR

Technique of Operation (Tenorrhaphy)

Primary tendon repair should be done promptly. Traumatic [illegible] contaminated and after a few hours will probably become infected. [illegible] it is usually unwise to attempt primary repair of tendons if the [illegible] four hours old. If this time limit has been passed and if the [illegible] hours has not been passed, the wound may be closed, but the [illegible] sutured. The fresh wound should be carefully prepared as [illegible]

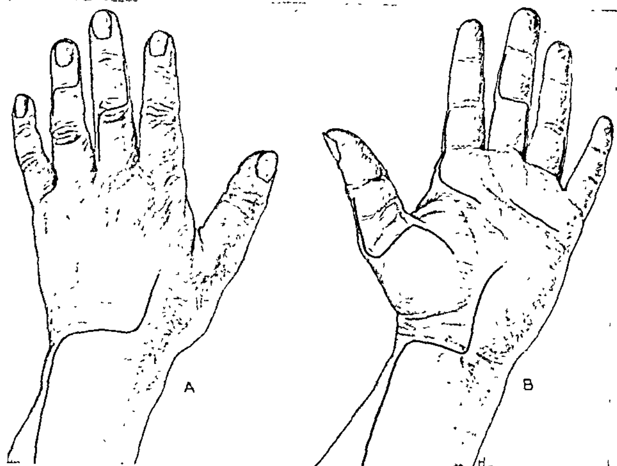


FIGURE 102. Lines of incision in hand and forearm to expose injured tendons and nerves. Skin incision should follow closely the skin creases. (Redrawn from Mason. Surg., Gynec. & Obst.)

Treatment of Fresh Wounds. The preparation and operation are best done under general anesthesia.

To locate the ends of the severed tendons and to furnish adequate room for tendon repair, it may be necessary to enlarge the primary wound. Incisions should be made in locations where the resultant scar will not contract and cause loss of function (Figs. 102, 103).

The methods of tendon suture described by Bunnell (Fig. 104) and Mason (Fig. 105) are satisfactory. In the former the end of the tendon is grasped with a hemostat and held while the suture is being placed. The portion in the grasp of the hemostat is then cut away, and the suture is passed through the tendon to emerge at the cut end. The two ends of the suture are then continued into the opposite end of the tendon and brought out at the same spot on the tendon surface and tied. This procedure avoids placing knots between tendon ends. In the method described by Mason the suture first grasps a small bundle of peripheral tendon fibers about 1 cm. from the cut end and is tied. With a straight needle the suture is then passed through the tendon and emerges on the opposite side about 0.5 mm. higher than the level of the knot. A similar suture is placed on the opposite side of the tendon. Each suture emerges above the knot of the other to give it fixation and stability. Similar sutures are placed in the opposite end of the severed tendon, and the tendon ends are approximated by tying the sutures and uniting the cut ends accurately with interrupted sutures. The tissues to cover the repaired tendon are carefully closed with interrupted sutures. Drainage

is not used. A third method of tendon suture with silk used by Coventry and Beck is shown in Figure 106.

Fine silk is the suture material commonly used for tendon repair. Sizes 5–0 or 6–0 silk, with a tensile strength of 5 to 6 pounds, are satisfactory. Bunnell has described a technique of tendon repair using stainless steel wire pull-out sutures (Fig. 107). Wire causes less tissue reaction than silk and can be completely removed after the tendon has healed. A pull-out wire is passed under the proximal loop of the stitch and passed through the skin with a needle. The suture wire is passed through a button on the skin surface and tied. At the end of three weeks the tendon is healed, and the suture is withdrawn with the pull-out wire after cutting the strands of wire beneath the button. If the wire is resistant to removal, a small rubber band attached to the wire and fixed a short distance away with adhesive will loosen the wire in twenty-four hours. For small tendons 35-gauge wire is used, and 30 or 28 for large tendons such as the biceps and Achilles.

Injuries to the flexor tendons in the distal portion of the palm and overlying the metacarpophalangeal joint present special problems. Because of the anatomic configuration in this area, the development of scar in the tendon and tendon sheath results in great disability. For this reason some authorities believe that primary tendon

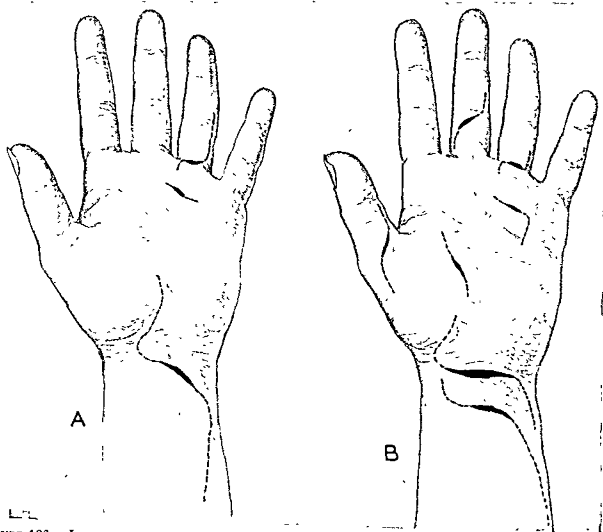


FIGURE 103. Incisions to enlarge hand and forearm wounds. (Redrawn from Mason: Surg., Gynec. & Obst.)

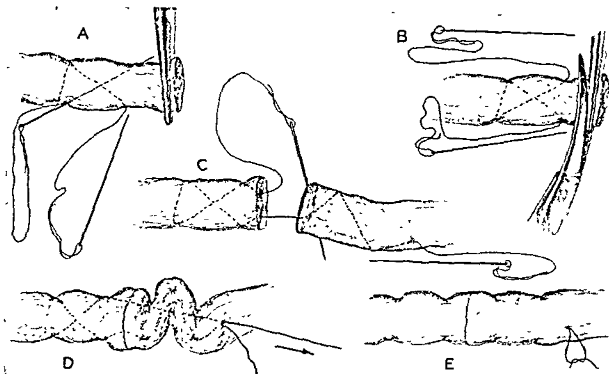


FIGURE 104. Bunnell's technique of tendon suture. *A*, With a needle on each end a suture is passed through the tendon 2 to 4 times and emerges at the end of the tendon. *B*, The end of tendon grasped in hemostat is removed. *C*, Suture emerges at one end of tendon and is passed into the opposing end *D*, Suture has been passed through both ends of tendon, and both ends of suture emerge at same spot on tendon. *E*, Appearance of tendon after suture is placed and tied. (Redrawn from Bunnell's Surgery of the Hand, J. B. Lippincott Company.)

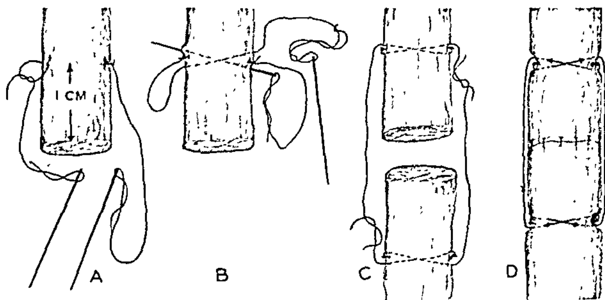


FIGURE 105 Technique of tendon suture The longitudinal pull of the sutures is converted into a transverse pull across the center of the tendon (Redrawn from Mason Surg., Gynec. & Obst.)

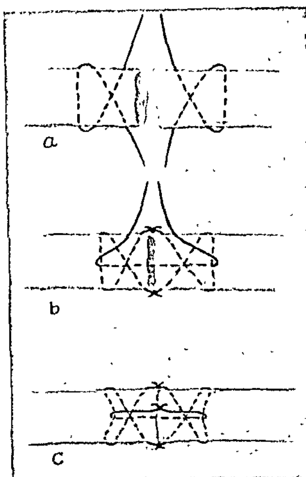


FIGURE 106. Technique of primary tendon suture. *A*, Silk sutures placed in ends of severed tendons. *B*, Sutures tied with just enough tension to approximate ends of tendon. Third, or "stay," suture in place. *C*, "Stay" suture tied. This suture is used for additional strength and for closer approximation of the tendon ends. (Redrawn from Coventry and Beck· J.A.M.A , Vol. 135.)

suture in this region should not be attempted and that secondary tendon grafting between the proximal palmar area and tip of the finger should be done as an elective procedure. It generally is agreed that if primary repair is to be done, it should be reserved for clean, incised wounds seen early after injury. When a wound is dirty, or if considerable time has elapsed since injury, thorough cleansing and débridement with simple closure of the skin edges is wiser. If primary suture is to be attempted, only the flexor profundus tendon is sutured.

When repairing severed flexor tendons divided in the digital sheath, it is unnecessary to suture the flexor sublimis tendon. The flexor profundus tendon is united, and the distal end of the sublimis is removed distal to the point of tendon suture. The proximal end of the sublimis may be left free or united to the profundus. After the profundus tendon has been sutured, Mason excises a section of the fibrous digital sheath to provide a subcutaneous fatty bed for the healing tendon (Fig. 108).

Technique of Operation for Rupture of Long Head of Biceps Brachii

An incision 10 to 12 cm long is made over the anterior border of the deltoid muscle, extending downward from the top of the shoulder. By separating the deltoid and pectoral muscles and rotating the arm inward the head of the humerus and bicipital groove are exposed. The rupture of the head may occur at its attachment to the glenoid, in the bicipital groove or at the musculotendinous junction. By incising the sheath the proximal end of the tendon can usually be located easily. The distal end retracts and may be drawn down into the arm. When the rupture is in the bicipital

groove or at its muscular attachment, it may be sutured with silk. If the tendon ends cannot be approximated, a tendon or fascial graft may be used to bridge the defect.

If the tendon is ruptured at its attachment to the glenoid or within the joint, Gilcreest lists five methods of repair which may be used. They are suture of the long head of the tendon (1) to the short head of the biceps; (2) to the coracoid process (Fig. 109); (3) to the pectoralis major; (4) in the sulcus intertubercularis; and (5) to the deltoid. Silk or cotton sutures are recommended for these operations.

As postoperative treatment the arm is immobilized with the elbow flexed to prevent abduction of the shoulder and extension at the elbow. Active and passive motion is begun cautiously after three weeks. Within eight weeks active exercise is permitted. Physical therapy is indicated to hasten recovery.

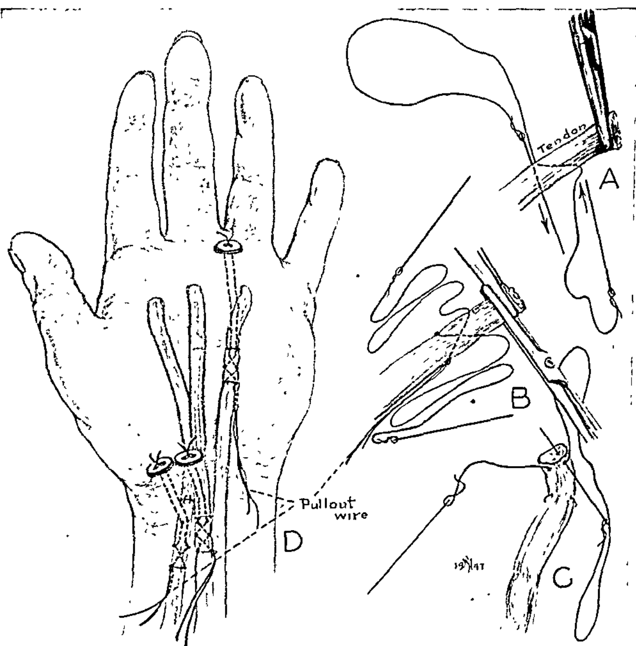


FIGURE 107 Bunnell's technique of using removable stainless-steel wire tendon sutures *A*, End of tendon is held in hemostat while wire suture is placed *B*, End of clamped tendon is removed *C*, Wire suture is passed through end of severed tendon *D*, Three types of tendon suture with wires and pull-out wires in place. (Redrawn from Bunnell's Surgery of the Hand J B Lippincott Company)

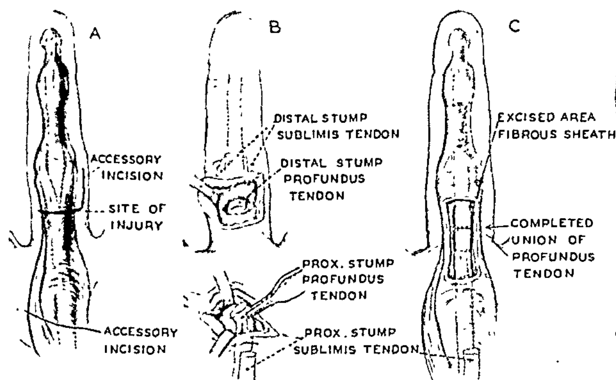


FIGURE 108. Technique of repair of flexor tendons divided in digital sheath. *A*, Accessory incisions are made to permit the exposure of tendons in finger and palm. *B*, The proximal end of the sublimis tendon is shortened and allowed to retract or is sutured to the side of the profundus tendon. The distal end of the sublimis is excised distal to the suture line in the profundus tendon. *C*, Over the site of the suture of the flexor profundus digitorum tendon a window about 1.5 cm long is excised from the fibrous sheath. When the skin is closed, the subcutaneous fat is in contact with the sutured tendon. (Redrawn from Mason: Surg., Gynec. & Obst.)

Technique of Repair of Supraspinatus Tendon (Codman)

Complete rupture of the supraspinatus tendon is an indication for operation.

An incision 6 cm. long is made through the anterior fibers of the deltoid muscle, extending downward from the acromioclavicular joint. An incision of this length will preserve the circumflex nerve supply to the anterior portion of the deltoid muscle. If necessary for adequate exposure, the upper end of the incision may be extended posteriorly over the acromion process. After splitting the fibers of the deltoid the subdeltoid bursa is exposed and incised. If a complete rupture of the supraspinatus tendon exists, the articular surface of the humeral head will be visible through the rent in the floor of the bursa.

The end of the ruptured tendon is exposed in the subacromial space by rotating the arm internally. The fractured end of the tendon is removed, and two to four heavy silk mattress sutures are placed in the tendon for traction until the site of attachment to the tuberosity of the humerus is prepared. Holes are drilled in the tuberosity, and the silk sutures, already placed in the tendon, are passed through the drill holes and tied. Strips of fascia lata may be used as sutures instead of silk. The wound is closed with fine silk.

As after-treatment a pillow is placed in the axilla to hold the arm in abduction and limit internal rotation. Guarded exercise in the "stooping arm swinging" position may be started on the second postoperative day. Healing should be sound within three weeks.

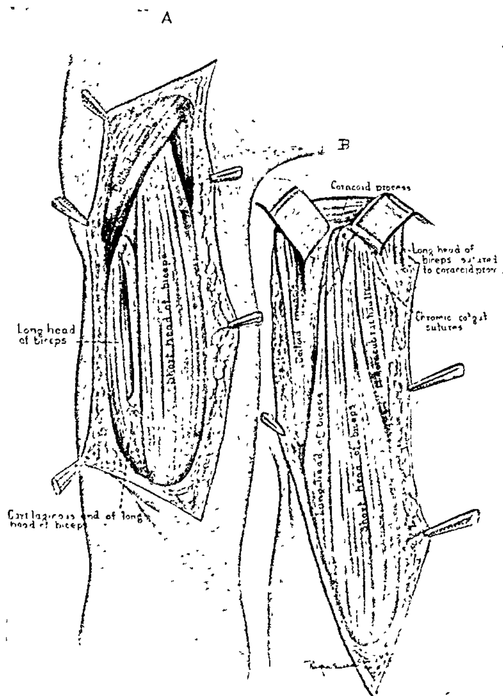


FIGURE 109 Technique of suture of long head of the biceps to the coracoid process. *A*, The long head of the biceps has been ruptured at its glenoid attachment and folded downward *B*, The long biceps tendon has been passed through the short head and sutured to the coracoid process and upper fibers of the short head (Gilcreest Surg , Gynec & Obst By permission of Surgery, Gynecology and Obstetrics)

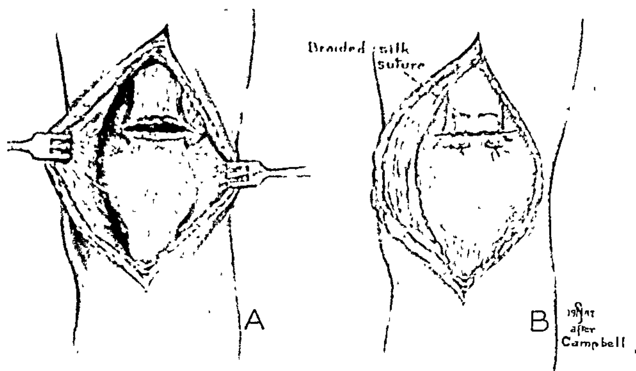


FIGURE 110. Technique of suture of ruptured quadriceps tendon. *A*, Curved incision has been made lateral to the tendon. Reflected skin flap exposes the defect in the tendon. *B*, The rupture is repaired with mattress sutures of medium heavy silk. (Redrawn from Campbell· Operative Orthopedics, C. V. Mosby Company.)

Technique of Operation for Rupture of Quadriceps Femoris Tendon

The site of the ruptured tendon may be exposed through a transverse or longitudinal incision. Campbell advises a longitudinal incision parallel with the inner border of the quadriceps tendon and patella (Fig. 110). The ends of the tendon are usually found separated 2 to 3 cm. Mattress sutures of medium heavy silk are used to unite the tendon ends. Strips of fascia lata may also be used as suture material. The wound is closed with fine silk.

The postoperative treatment is important. A posterior splint is worn for three weeks. Guarded active and passive movements may then be started, and walking with a brace may be permitted. Flexion is gradually increased to 90 degrees in three months, and complete range of motion may be expected in six months to one year.

SECONDARY TENDON REPAIR

Technique of Operation (Tenorrhaphy or Tendoplasty)

In secondary tendon repair general anesthesia is usually desirable. A tourniquet should be used when possible. A blood pressure cuff is satisfactory.

Scar tissue is excised, and all anatomical structures are identified. Tendons severed or destroyed by injury or infection are usually separated by muscle contraction and contracture. If the tendon ends can be approximated without tension, they may be united as described for primary suture.

When tendon grafts are necessary, the technique of Bunnell is satisfactory (Fig. 111). Grafts may be obtained from the palmaris longus or long extensors of the toes. If a flexor tendon is to be grafted into a finger, the sublimis is sacrificed and used as

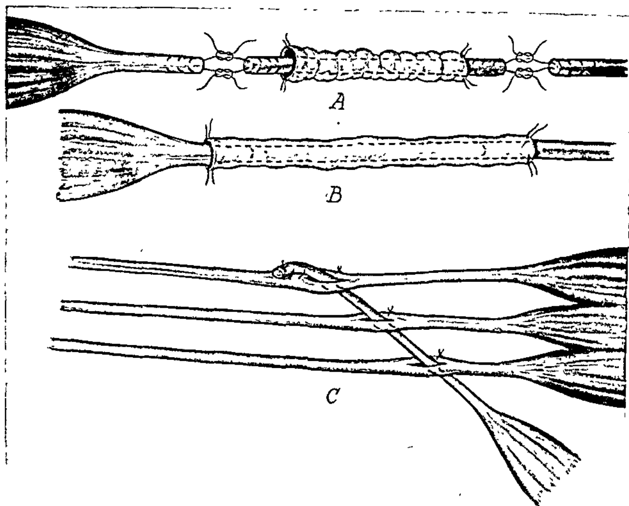


FIGURE 111. *A*, Free tendon graft to bridge a long tendon defect. Paratenon is retracted to place sutures in tendon *B*, Suturing has been completed, and the paratenon has been extended along the tendon and fixed to surrounding tissues with fine sutures of silk. *C*, Method of tendon suture by perforation. The tendon of the flexor carpi ulnaris is attached to the extensors at the wrist to furnish extension to the fingers. (Redrawn from Bunnell: Lewis' Practice of Surgery, W. F. Prior Co , Inc)

a graft for the profundus. When the palmaris or extensor tendons of the toes are used, the paratenon is removed with the tendon segment. If the paratenon is not available with the tendon, fat may be removed from over the triceps tendon and made to surround the graft as a loose-fitting tube.

REPAIR OF FINGER TENDONS

General Considerations

As previously stated, primary suture of tendons in the distal palm and proximal finger is indicated only in the presence of clean lacerations seen early after injury, and only the profundus tendon is approximated. In all other instances, and indeed some authorities believe in all instances, use of tendon grafting as a secondary elective procedure is indicated.

Before attempting repair of finger tendons, there should be correction of finger deformities and mobilization of stiff joints. If a finger is stiff, extensively scarred and shows a poor circulation with thin, shiny red skin, sensory disturbance, and tenderness, it is rarely suitable for tendon repair. If such a finger is painful or in the way, amputation is advisable.

If a tendon repair is to be successful, or even partially successful, it is necessary that the tissues of the finger which will surround the repaired tendon be soft and pliable and have a good blood and nerve supply. Preliminary pedicled grafts to restore the soft tissues of the finger may be advisable in selected cases. Since tendoplasty cannot be successful in the presence of infection, ample time should be given for preparing the part before operation. This may require several months.

Technique of Tendon Graft for Repair of Flexor Tendon of Finger (Fig. 112)

Lateral incisions are made for the repair of the flexor tendon of the finger. It is important to avoid injury to the vessels and nerves of the finger. Median longitudinal incisions are never desirable.

The tendon pulleys are located along the central portions of the phalangeal segments; hence, to avoid cutting these structures, the lateral incisions are made opposite the joints (Bunnell). If an incision is necessary in the palm, it should follow palmar creases; L-shaped incisions are satisfactory.

The damaged tendon is completely removed by careful dissection. Bunnell has designed a special tendon stripper made of cork borers which are used to remove scarred tendons and construct a tunnel for the tendon graft.

Tendon grafts may be obtained from the sublimis tendon, palmaris longus, long extensors of the toes or tubularized triceps. When possible, the paratenon should be removed and transplanted with the tendon graft. If this is not possible, paratenon fat may be obtained from the fat over the triceps tendon.

After accurate measurement the tendon graft is removed and placed in the finger. The graft is sutured to the finger tendon with silk and, when necessary to attach to bone, is fixed with silk passed through a hole drilled in bone, or the Bunnell "pull-out" wire technique may be used (Fig. 107). The sublimis tendon, if present, is excised to make room for the transplant to the longus tendon. When necessary, an artificial pulley may be constructed from a free tendon graft.

Success of tendon repair depends much upon the after-treatment. To avoid too much mobilization of the fingers, which promotes the development of adhesions, the

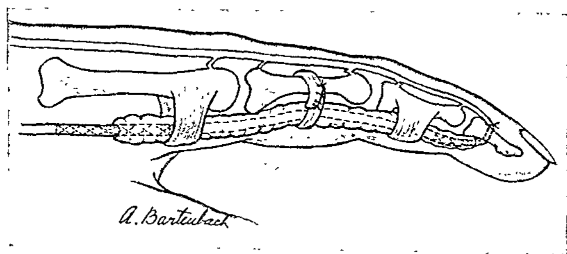


FIGURE 112. Diagram showing method of repair of a flexor tendon in a finger by a free graft of tendon plus its paratenon The damaged tendon has been removed, and the new tendon has been sutured in place. A new pulley has been constructed from a free tendon graft. (Redrawn from Bunnell).

wrist is fixed in flexion with a splint. Too much motion of the tendons is thus prevented, and moderate motion is encouraged. The splint is worn for four weeks, when physical therapy is begun. A galvanic current may be used which causes sudden sharp contractions, breaking light adhesions.

TENOTOMY

Technique of Operation

Tenotomy may be done by open operation or subcutaneously. For open tenotomy an incision is made parallel to the tendon. The tendon sheath is opened, and the tendon is divided transversely. The wound is closed with fine catgut or silk.

For subcutaneous tenotomy, sharp- and blunt-pointed tenotomes are advisable. With the sharp tenotome a stab wound is made at the side of the tendon to be cut. The blunt tenotome is then inserted beneath the tendon, and, while the tendon is put on a stretch, it is divided toward the skin by a careful sawing motion (Fig. 113). The wound may be closed with a stitch. The part is held in proper position with splints or a cast.

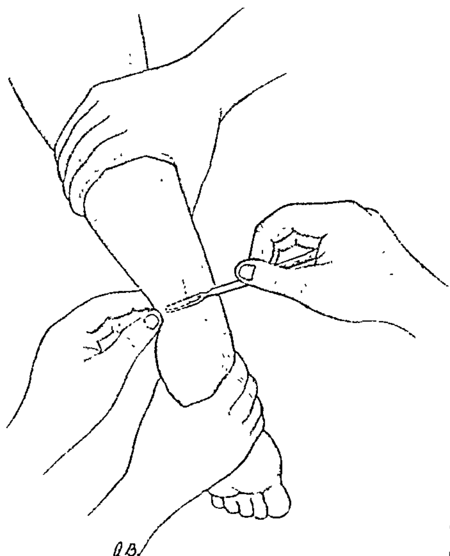


FIGURE 113. Subcutaneous tenotomy of the tendo achillis

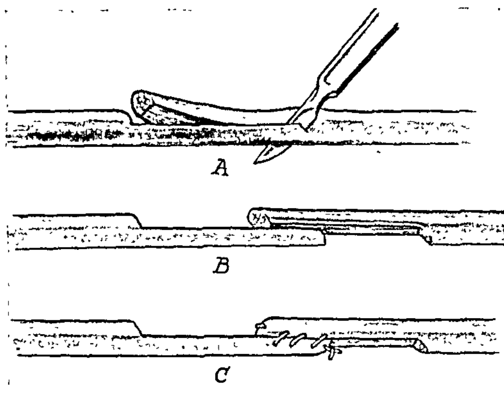


FIGURE 114. Method of tendon lengthening. (Redrawn from Bunnell: Lewis' Practice of Surgery, W F. Prior Co., Inc)

TENDON LENGTHENING

Technique of Operation

Tendons may be lengthened by direct transplantation of a segment of tendon or by a plastic operation. The methods of tendon lengthening are best presented by illustrations (Figs. 114, 115).

ATTACHMENT OF TENDON TO BONE

Technique of Operation (Bunnell)

The periosteum is incised and raised to expose the bone. The scraped end of the tendon should be in contact with bone. When possible, a chip of bone is removed with the tendon from its original insertion to be transplanted against denuded bone at the site of its new insertion. Mayer slits the insertion of the old tendon and through this opening raises the periosteum and gouges out a gutter in the bone. The transplanted tendon end is fixed in this prepared bed with silk sutures (Fig. 116). The slit in the old tendon is used to close over the end of the transplanted tendon

Other methods of tendon attachment vary with the type of tendon and bone to be united. A drill hole large enough to pass the tendon through may be made. An osteoperiosteal door may be raised, the bone guttered, and drilled so that the tendon may be fixed in a long gutter by passing silk sutures through the bone (Figs. 116, 117).

Special care should be given to the tension of tendons when they are attached to bone. Mayer stated that the tension should be zero when the tendon is fixed to an

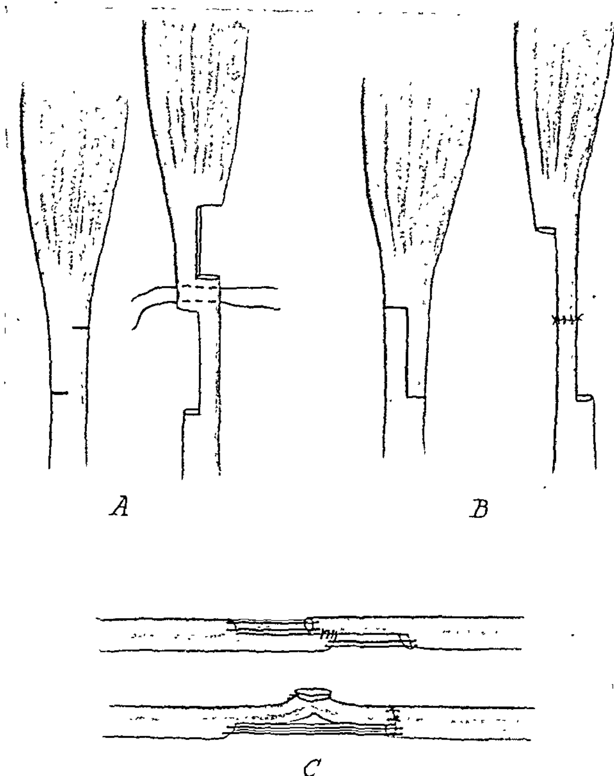


FIGURE 115 A, Bayer's method of tendon lengthening Lateral incisions are made, and by traction the fibers of the tendon glide past each other The ends are reinforced with silk sutures B, Tendon lengthening by hemitransverse section, median splitting and end-to-end suture C, Tendon splitting and reinforcement with silk sutures. (*Redrawn from Bickham's Operative Surgery*)

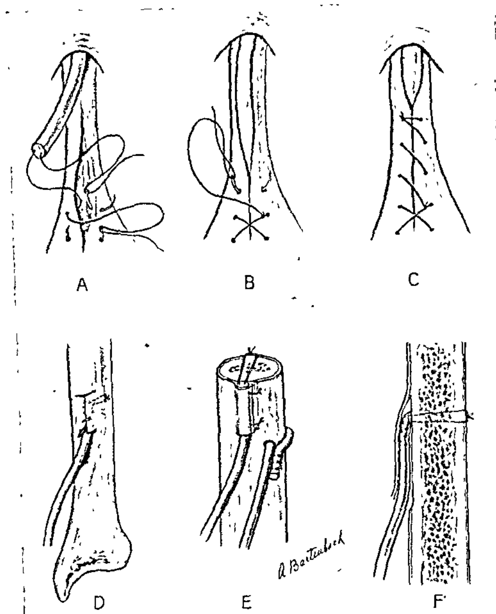


FIGURE 116. *Above*, Mayer's method of fixing tendon to bone at the insertion of another tendon. The peroneus longus is drawn through the sheath of the tibialis anticus. *A*, Insertion of tibialis anticus is incised, and a gutter is gouged in the bone. Heavy needles are used to pass silk sutures through bone and ligamentous tissue *B*, The first suture is tied, and the incision in the tibialis anticus is closed and sutured to the peroneus longus *C*, Fixation completed.

Below, Other methods of fixing tendon to bone *D*, Osteoperiosteal flaps are raised, the bone is gouged, and the tendon is sutured to the bone through 2 drill holes. *E*, A lateral osteoperiosteal flap covers the tendon, which lies in a gutter in the bone. The tendon is fixed with sutures passed through drill holes in the bone *F*, Longitudinal osteoperiosteal flap with sutures placed through drill holes in the bone (Redrawn from Bunnell· Lewis' Practice of Surgery, W F Prior Co., Inc.)

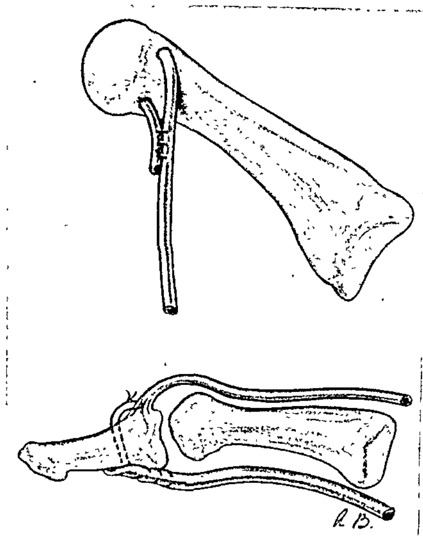


FIGURE 117. Method of fixing tendon to bone.

extremity in its natural position. Too much tension may cause separation at the point of attachment, or atrophy of the transplanted tendon.

TENDON FIXATION

General Considerations

Some cases of paralysis resulting in imbalance and deformity may be corrected by the fixation of tendons to bone. Such operations are valuable for certain types of deformity of the foot and ankle, such as talipes equinus, talipes calcaneus, and lack of apposition of the thumb. Tendon fixation for paralytic talipes equinus is described to illustrate the method.

Technique of Tendon Fixation for Talipes Equinus (Fig. 118)

An incision is made over the tibialis anticus tendon. The tendon is severed at its junction with the muscle, and the distal end is fixed to the tibia by making an osteoperiosteal flap and drill hole in the bone. The peroneus longus and brevis are freed, passed beneath the annular ligament and fixed to the fibula by passing the tendon ends through a drill hole. The foot is held at 15 degrees below a right angle.

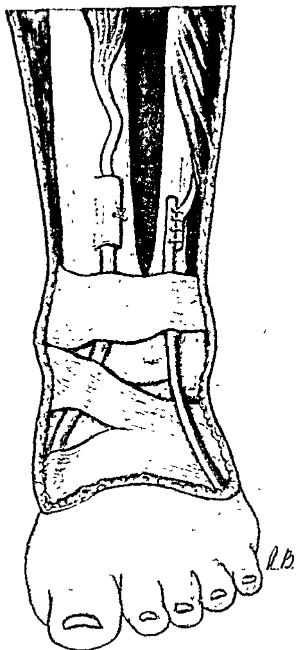


FIGURE 118. Tendon fixation operation for paralytic talipes equinus The peroneus longus tendon anterior to the external malleolus is passed under the annular ligament to be fixed to the fibula. The tibialis tendon is fixed to the tibia by sutures passing through drill holes in the bone (Redrawn from Bunnell: Lewis' Practice of Surgery, W. F. Prior Co, Inc.)

TRANSPLANTATION OF TENDONS

General Considerations

For a tendon transplantation to be successful, it must be done with the least possible trauma to the tendon and the new tendon bed. Following the lead of Biesalski, Mayer has developed what he terms a *physiologic* method of tendon transplantation. To avoid injury to the tendon to be transplanted, a long incision is usually made, and the tendon is carefully separated from its mesotenon by sharp dissection. Trauma to the tendon, especially at its mesotenon attachment, is carefully avoided to prevent subsequent adhesions. The sheath of the tendon to be replaced is opened, and the tendon being transplanted is drawn through with as little trauma as possible so that the gliding function may be preserved. The tendon is attached to bone at the insertion of the paralyzed muscle.

Such tendons as the extensor digitorum longus, extensor hallucis longus and the palmaris longus may be transplanted with the paratenon intact.

Bunnell outlines certain conditions that must be observed for successful transplantation as follows:

1. A transplanted tendon cannot correct a deformity. Before the tendon is transplanted, the *deformity of joints and ligaments must be thoroughly* corrected by breaking up adhesions, severing ligaments, bending the joints around by making wedge resections, and so on, until the normal position of the limb can be maintained without strain on the tendon. It may be necessary to combine with the transplantation other operations, such as tendon fixation or arthrodesis, to accomplish results.
2. A small muscle or semiparalyzed one cannot do the work of a large or healthy one. If muscle balance is not restored, the deformity will return.
3. When more than three muscles or more than one muscle group in a leg is paralyzed, tendon transplantations are of little, if any, benefit It is better to do a tendon fixation, an astragalectomy, an arthrodesis or other bone operations in combination. In extensive paralyses the stabilizing operations are of much more importance than are operations on the tendons.
4. A semiparalyzed muscle looks pink as compared with the red of a healthy muscle and cannot functionate sufficiently for a transplantation.
5. If muscles are not strong enough for the desired function, increased leverage should be given them
6. If a tendon transplant is in contact with bone surface or if it passes through a small hole in a ascial septum, it will become adherent and hamper movement.
7. The tendon transplant must *pull in as near a straight line as possible or it will lose mechanical* efficiency. An angulation in the course of the tendon or muscle can be remedied by freeing the attachment of the muscle for a distance upwards
8. In poliomyelitis adequate postural treatment should be kept up for at least two years before transplantations are done, since many paralyzed muscles will recover when relieved of the overstretching.
9. The attachment of the tendon must be strong enough to allow early motion and last until physiologic union is sufficiently strong This, in the foot, takes two months The tendon should be protected from strain for two months and a brace worn for a year, since there is a strong tendency for the foot to relapse into the original deformity. Gentle movement should be instituted early (within one to two weeks), or adhesions will bind the tendon in its bed.
10. The patient should be re-educated in the use of the transplanted muscle in its new function or *he may not learn its use* *

Tendon transplantations are commonly used for deformities of the foot and ankle such as talipes varus, talipes equinus and talipes calcaneus. Paralysis of various muscles of the lower and upper extremities may be partially corrected by tendon transplantation to restore muscle balance. Examples of common types of tendon transplantation are here described.

TRANSPLANTATION OF TIBIALIS ANTICUS TENDON FOR PARALYSIS OF PERONEAL MUSCLES

Technique of Operation (Fig. 119)

The insertion of the tibialis anticus tendon is exposed through a 5-cm. incision over the lower medial portion of the internal cuneiform bone. The tendon is divided at its insertion on the plantar surfaces of the internal cuneiform and first metatarsal.

A second incision 8 cm. long is made in the midline just above the ankle The sheath of the tibialis anticus tendon is opened, and the tendon is withdrawn with as little trauma as possible.

A third incision 5 cm. long is made over the cuboid bone exposing the sheath of

* From Lewis' Practice of Surgery, W F Prior Co, Inc, Hagerstown, Md, publishers

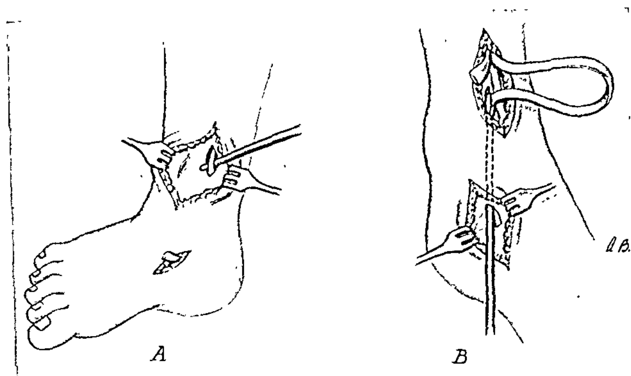


FIGURE 119 Transplantation of tibialis anticus tendon for paralysis of peroneal muscles. The insertion of tendon is detached and reinserted into lateral side of foot. (Redrawn from Campbell's Operative Orthopedics)

the extensor digitorum longus tendons. This sheath is incised, and a curved hemostat is inserted upward to the incision in the midline of the leg. Here the sheath is again opened, and the freed tibialis anticus tendon is drawn downward in the sheath to be inserted into the cuboid bone. A drill hole is made in the cuboid, and through this hole the end of the tendon is passed and fixed to itself by silk sutures. If the tendon is short, it may be scarified and sutured beneath the periosteum over the cuboid. Before attaching the end of the tendon to the bone, the foot is placed in the corrected position, and the tendon is attached without tension.

The foregoing procedure may be combined with operation upon the bones and joints when necessary to correct deformity. The foot is placed in the corrected position in a cast, and after six weeks a brace is fitted to be worn at least six months.

TRANSPLANTATION OF THE PERONEUS LONGUS TENDON FOR PARALYSIS OF THE TIBIALIS ANTICUS MUSCLE

Technique of Operation (Fig. 120)

In the transplantation of the peroneus longus tendon for paralysis of the tibialis anticus muscle, an incision 5 cm. long is made in the lateral border of the foot over the calcaneocuboid joint. The peroneus longus tendon is severed just beyond the point where it passes beneath the inferior surface of the cuboid bone.

A second incision 8 cm. long is made in the midline above the ankle. The peroneus longus tendon is identified at its musculotendinous junction. The sheath is incised, and the tendon is withdrawn from the wound.

A third incision 6 cm. long, made parallel with the tibialis anticus tendon over

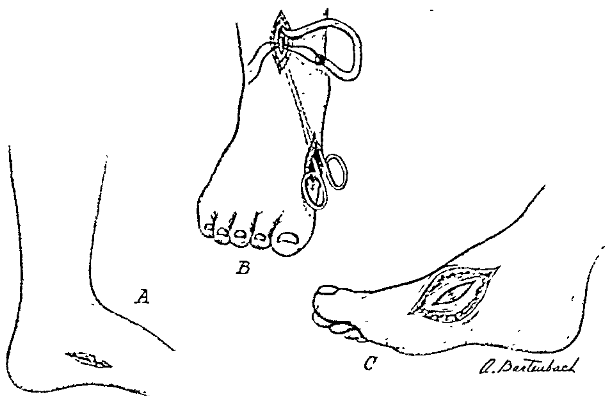


FIGURE 120. Transplantation of peroneus longus tendon for paralysis of tibialis anticus muscle. *A*, Incision for section of peroneus longus tendon at level of cuboid bone. *B*, Peroneus longus tendon is withdrawn through an incision in midline of leg above ankle and drawn through the sheath of the tibialis anticus tendon through a third incision over the first cuneiform bone *C*, Tendon attached through a drill hole made in the first cuneiform bone. (Redrawn from Campbell's Operative Orthopedics)

the medial cuneiform and base of the first metatarsal, will expose the tendon near its insertion beneath these two bones. The sheath of the tendon is opened, and with a tendon carrier or curved clamp the peroneus longus tendon is drawn through the tibialis anticus tendon sheath to the third incision. A drill hole is made in the medial cuneiform, and through this the peroneus tendon is drawn and fixed with silk.

Before fixing the tendon to bone, the foot is placed in slight adduction and dorsiflexion. The foot and leg are immobilized in plaster for three weeks and supported with a brace for several months.

TENDON TRANSPLANTATION FOR PARALYSIS OF TIBIALIS ANTICUS

Technique of Operation (Steindler) (Fig. 121)

An incision 8 cm. long is made on the dorsum of the foot between the tibialis anticus and extensor hallucis longus tendons. The sheaths of these two tendons are opened, and the opposing edges of the sheaths are sutured together. This makes a new tendon sheath bed for the inserted tendons. The extensor hallucis longus tendon is severed at the metacarpophalangeal joint. The sides of the two tendons are scarified and united with sutures. The proximal end of the extensor hallucis tendon is implanted in a groove made in the internal cuneiform near the insertion of the tibialis anticus. The united tendon sheaths are sutured over both tendons.

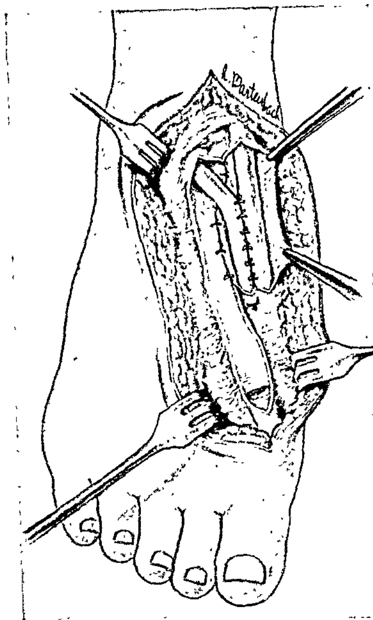


FIGURE 121. Steindler's operation for weakness of the tibialis anticus muscle. The extensor hallucis longus is divided and sutured to the tibialis anticus tendon. (Redrawn from Campbell's Operative Orthopedics.)

TENDON TRANSPLANTATION FOR PARALYSIS OF THE GASTROCNEMIUS MUSCLE

Technique of Operation (Ober)

The tendons of the peroneus longus and tibialis posticus muscles are severed near their insertions through incisions over the tendons. They are freed up to their muscle junctions. The medial incision is continued backward, exposing the tendo achillis and the os calcis. A hole large enough to admit the tendons is drilled through the os calcis near the insertion of the tendo achillis. The two freed tendons are passed down through the tendo achillis compartment, crossed behind the tendon and passed through the drill hole in the os calcis. The tendon ends are sutured to the tendo achillis with silk.

In addition to a tendon transplantation, a stabilizing foot operation is often

necessary. After operation the foot is immobilized for four to six weeks and then fitted with a brace. A free graft of fascia lata between the hamstring muscles and the tendon of the gastrocnemius may be used to produce plantar flexion of the foot.

TRANSPLANTATION OF THE TENSOR FASCIAE FEMORIS AND SARTORIUS MUSCLE FOR PARALYSIS OF THE QUADRICEPS EXTENSOR MUSCLE

Technique of Operation (Ober) (Fig. 122)

The first incision extends from the tibial tubercle, over the insertion of the sartorius muscle, upward along the course of the muscle to the junction of the middle and upper thirds of the thigh. The insertion of the sartorius muscle is severed, and the muscle is freed upward to the middle of the thigh. The patellar and quadriceps extensor tendons are exposed through the same incision.

A second incision 15 cm. long is made extending from the ligamentum patellae

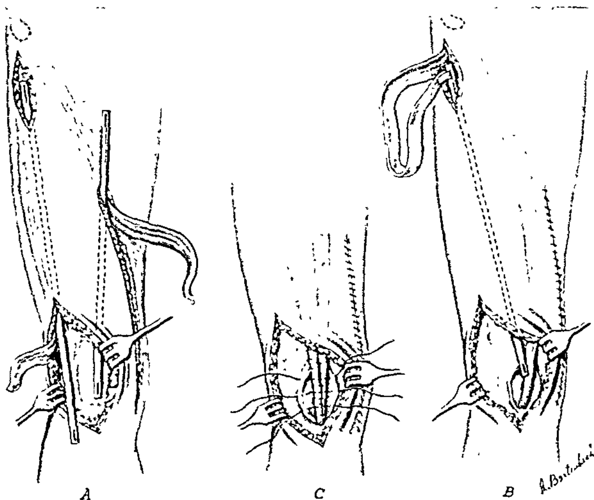


FIGURE 122 Transplantation of tensor fasciae femoris and sartorius muscle for paralysis of the quadriceps extensor muscle *A*, The iliotibial band is severed at its insertion into the fibula through an incision lateral to the knee The sartorius muscle is divided at its insertion through a long medial incision and freed to the midthigh *B*, The iliotibial band and sartorius are drawn through subcutaneous tunnels to the patella *C*, The iliotibial band and sartorius are sutured to the ligamentum patellae and covered with reflected aponeurosis and periosteal flaps from the patella (Redrawn from Ober: New England J Med)

upward and outward over the iliotibial band. A strip of the iliotibial band 2 cm. wide is dissected free from the head of the fibula.

A third incision 6 cm. long is then made over the upper iliotibial band at its junction with muscle. The band of fascia is dissected free and withdrawn from the upper wound through a subcutaneous tunnel. The belly of the tensor fasciae femoris muscle is freed.

The inner margin of the second incision is dissected medially to expose the quadriceps tendon and patella. An incision, beginning in the quadriceps tendon and extending downward over the patella into the patellar tendon, is made. The margins of this incision are reflected 1.5 cm. Silk sutures are placed in the free ends of the sartorius muscle and iliotibial band, and these structures are passed subcutaneously to the patella. With the knee extended and the thigh flexed to relieve tension, the sartorius is sutured to the patellar tendon. Over the sartorius the iliotibial band is also sutured to the patellar tendon. The medial and lateral margins of the iliotibial band are sutured to the edges of the patellar aponeurosis.

The knee is splinted in extension for three weeks. The splint is then removed for passive exercise and physical therapy. At the end of eight weeks a brace is fitted and weight-bearing permitted.

BASEBALL FINGER

Technique of Repair of Baseball Finger (Fig. 123)

Avulsion of the extensor digitorum communis tendon may occur at its attachment to the distal phalanx or may carry with it a chip of bone from the dorsal base of the phalanx. The resulting deformity is quite characteristic and is called baseball or mallet finger. When the condition is treated early, splinting of the finger in extension with the distal phalanx in hyperextension will usually result in healing. Otherwise open repair is necessary.

A dorsal incision curved distally is made. The end of the tendon is secured and sutured beneath the periosteum to the base of the distal phalanx with silk passed

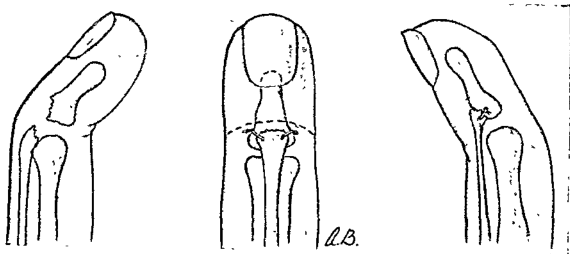


FIGURE 123. ... fixation with silk s... Orthopedics)

through a drill hole in the bone. If a chip of bone is attached to the tendon, the surfaces are freshened, and the bone is replaced and fixed in the phalangeal defect.

The skin incision is closed with silk. The distal phalanx is splinted in hyperextension for three to four weeks. After removal of the splint physical therapy is indicated to restore function. Failures are common.

TRIGGER FINGER

Trigger or snapping finger is due to a small swelling on a tendon which prevents its smooth passage through the superficial flexor tendon or tendon sheath. There may be a constriction of the tendon sheath due to infection or trauma. Rest of the finger may sometimes effect a cure.

Technique of Operation

An incision is made in the lateral aspect of the finger, avoiding the vessels and nerve. The nodule on the tendon is removed, or the constricted opening through which it passes is enlarged. A portion of constricted tendon sheath may be resected. The after-treatment consists in splinting for a week to minimize pain and swelling. Physical therapy and active use will hasten return of function.

GANGLION

A ganglion is a small, benign cystic swelling usually adjacent to or connected with a joint. It is commonly found on the dorsum of the wrist, but may be found in the palm, on the dorsum of the foot or in the popliteal space.

Technique of Excision

Local anesthesia is usually satisfactory. The ganglion is exposed through a transverse incision. Dissection is made close to the ganglion to avoid injury to nerves, tendon sheaths and tendons which may be involved. The ganglion is thoroughly removed down to the bone. It is often connected with a joint, and, unless completely removed down to the joint synovia, it may recur. If tendon sheaths are opened, they should be repaired. The subcutaneous tissues and skin are closed separately. Splinting is advisable for a week to reduce pain.

DE QUERVAIN'S DISEASE (FIG. 124)

Chronic stenosing tenosynovitis involving the abductor pollicis longus and extensor pollicis brevis tendons where they run through a ligamentous synovial-lined sheath over the prominence of the styloid process of the radius is known as de Quervain's disease. This condition, which probably results from chronic trauma, often results in great disability and frequently is resistant to conservative treatment.

Technique of Operation

Operation may be done under local or general anesthesia, and use of a tourniquet to provide a bloodless field is recommended. A short transverse incision is made

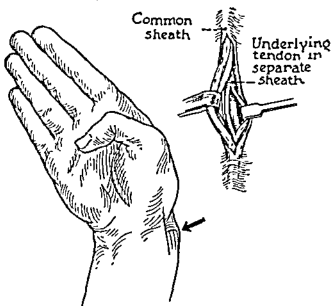


FIGURE 124. De Quervain's disease, or stenosing tenosynovitis of the extensor pollicis brevis and abductor pollicis longus as they pass over the radial styloid. It is important that all compartments of the tunnel be divided to ensure favorable results. (Davis: Christopher's Textbook of Surgery.)

through the skin across the wrist at the level of the radial styloid. When the skin has been divided, further dissection should be carried on in a longitudinal direction to avoid injury to branches of the superficial radial nerve. When the sheath has been exposed, this is divided longitudinally, and if greatly thickened, the anterior portion of the sheath should be excised. It is important to examine the tunnel carefully, since it may be divided into several compartments through which the tendons may pass. The two usual tendons may have separate slips, in which case these compartments must also be divided. Aberrant tendons have also been described. When the main compartment and all secondary compartments have been divided, the incision is closed. Splinting of the thumb for a week or ten days to permit healing is recommended.

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CHAPTER 8

Head and Neck

OPERATIONS UPON THE NOSE AND FACE

EPISTAXIS

General Considerations

Severe nasal bleeding may occur spontaneously or be secondary to nasofacial trauma. Bleeding may occur from either vessels of the nasal septum or the lateral nasal wall. Major arteries supplying the lateral nasal wall and septum enter the nose posteriorly and superiorly and course downward and inferiorly, so that bleeding from rents in these vessels posteriorly is much more brisk than in the anterior part of the nose, which, however, is a more frequent point of injury. Laceration of these vessels usually results from mucosal tears produced by displacement of underlying bony structures. Spontaneous severe epistaxis is usually complicated by arteriosclerotic vessels, hypertension or a bleeding tendency. These episodes are often the result of trauma produced by nose picking.

The simplest method of controlling such nasal bleeding when the point is visible, or can be made visible by spot suction, is cauterization with the actual or high frequency cautery after the area has been anesthetized either with topical cocaine or an intramucosal injection of procaine. In cauterizing such areas of the anterior septum, care must be taken not to cauterize too deeply for fear of producing a chon-

dritis in the underlying septal cartilage. If the bleeding point is not accessible to direct visualization and cautery (a frequent occurrence in posterior nasal bleeding), nasal packing becomes necessary.

Technique of Nasal Packing

Unless contraindicated by other injuries or shock, the patient should be placed in the sitting or semirecumbent position. Unless bleeding is severe, some attempt should be made to induce surface anesthesia in the nose by the use of topical 5 or 10 per cent cocaine. Cocaine is to be preferred over Pontocaine in these cases because of its own vasoconstrictive action. A posterior pack will be necessary to support the intranasal anterior packing in its posterior portion. Topical anesthesia to the pharynx and nasopharynx also must be induced either by the applicator or by spray method of application of cocaine to the mucosa in this area. A few moments spent in careful anesthesia of this type will be greatly appreciated by the patient.

A small rubber uretheral catheter is now introduced into the nares of the bleeding side and pushed backward until it is visible in the pharynx. The pharyngeal end is grasped with a hemostat and pulled out of the mouth. Both the nasal and oral ends are now clamped together with the hemostat so that the catheter will not be dislodged by a sudden movement of the patient. To the oral (eyelet) end of the catheter are now tied two of the three tapes on a lamb's wool postnasal pack. This is made by rolling lamb's wool into a roll measuring 4 by 3 by 3 cm. It is then tied like a bale of cotton with umbilical tape, with the tapes about 10 inches long.

One tape is cut off flush with the pack, leaving three attached. After the tapes have been tied to the catheter the hemostat is removed, and the catheter is pulled out of the nose, bringing the postnasal packing into the nasopharynx. This pack will have to be guided under the soft palate into the nasopharynx with the index finger of the physician's hand, while firm traction is made on the tapes presenting from the nose with the opposite hand. By firm traction on the tapes the lamb's wool is firmly impinged in the choana. This will seal the bleeding from the nasal cavity from the nasopharynx and will prevent the annoying bleeding into the pharynx with resultant strangling and coughing on the part of the patient. The third tape, which is attached to the postnasal pack which now lies in the mouth, is cut so that it hangs just below the soft palate. The purpose of this tape is for later removal of the postnasal pack, at which time this tape can be grasped with a hemostat and the pack pulled out of the nasopharynx into the mouth.

The bleeding nasal cavity is now packed firmly with ½-inch selvedge edge dry gauze with maximum pressure over the bleeding area. Control of bleeding is more apt to be affected by fibrin caught in the interstices of the dry gauze with clot formation than by pressure compression of the bleeding point. For this reason dry gauze is more effective than a greased gauze. An oval button approximately 2 by 3 cm. is now cut out of heavy-gauge sheet polyethylene, and two small holes are punched side by side in the center of it. Through each hole is passed one of the tapes presenting through the anterior nares of the bleeding side. The tapes are then tied firmly together over this plastic button, gently pressing it against the external nares. This serves to anchor the anterior packing.

During the time the packing is in place the patient should receive a broad-spectrum antibiotic. Packing should be left in for a minimum of three days. By this time it will be soaked with mucus and will be easily removed. The postnasal pack is removed by traction on the pharyngeal string.

In instances in which the nasal hemorrhage has been provoked by nasal fracture the volume of nasal packing must not be sufficient to displace the fractured bones laterally, or a wide, unsightly nose will result.

NASOMAXILLARY INJURIES

General Considerations

Facial fractures, excluding those of the mandible, are the result of direct violence, and since these bones overlie air-filled chambers or soft underlying tissues, they are generally depressed.

In massive facial injury, multiple fractures of the various bony components may occur. Total treatment must rest on careful clinical and radiologic examination. Standard x-ray projections used for paranasal sinuses, viz., Waters, Caldwell, lateral and verticomental with right and left zygomatic arch views, are the most valuable. If mandibular fractures are suspected, right and left mandible and temporomandibular joint x-ray films should be obtained.

Initial treatment should consist in control of bleeding and replacement of lost blood. Evaluation of the upper airways is of next importance, with resort to tracheostomy if there is the slightest doubt of their adequacy due to soft tissue obstruction at the base of the tongue or pharynx or due to edema from direct trauma to the larynx itself, or to loss of support of tissues in and about the base of the tongue, as in severely fractured mandible.

All nasomaxillary fractures should be reduced as soon as the patient's condition will permit. After one week nasal fractures are difficult to manage, and zygomatico-maxillary fractures after ten days. Delayed refracture and repositioning of bones seldom lead to a satisfactory result.

Patients should be administered an appropriate antibiotic from the time of injury until nearly healed. Soft tissue wounds of the face should have been closed. Where comminution of underlying bones has been such that open reduction and direct wiring become necessary, wounds of trauma may be used as a surgical access way to the fractures, provided of course the patient's condition will permit this amount of surgery. This minimizes scarring of the face.

Though these fractures may be reduced under local anesthesia, general anesthesia with the trachea intubated is to be preferred. Local anesthesia is difficult in traumatized tissues. Manipulation of fractures, especially nasal and maxillary ones, may incite bleeding into the nasopharynx, adding to the patient's discomfort and anxiety if he is conscious; and the volume of tissue involved frequently has innervation by all three trigeminal branches bilaterally, making adequate local anesthesia almost impossible. Also, adding fluid to tissues already edematous further complicates their adequate approximation.

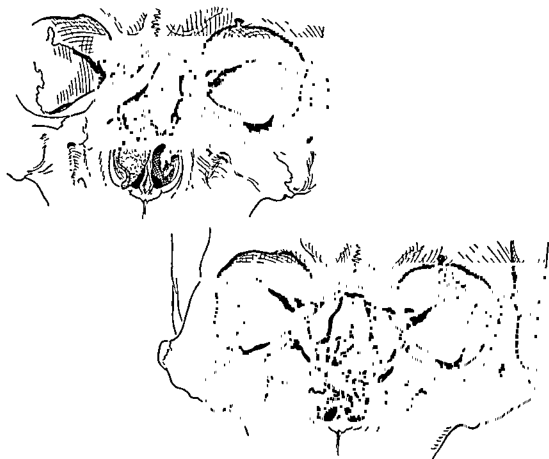


FIGURE 125. The usual displacement of the nasal bones and septum in lateral and anterior nasal fractures. (N. L. Rowe and H. C Killey Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company)

NASAL FRACTURES

General Considerations

Nasal fractures are either lateral or anterior. In lateral injuries the frontal process of the maxilla and the nasal bone on the affected side become detached at the sutures, causing this side of the nose to appear too long. On the opposite side distal to the impact, the nasal bone is driven into the maxilla and displaced medially, producing an apparent shortening of this side of the nose. The septum is usually buckled into an S-shaped position, causing varying degrees of separation of the septal components.

Anterior injury is brought about by direct violence on the bridge of the nose, causing fracturing at the nasofrontal sutures, with the nasal bones splayed outward. In this instance the profile of the nose is flattened, and the nasal bones may be driven deeply into the nasal cavities (Fig. 125).

Technique of Reduction

Walsham, right and left nasal forceps and Asche's septal forceps are the most valuable instruments in the treatment of nasal fractures (Fig. 126). Either a right or left Walsham forceps is introduced in the nasal cavity of the shortened side, with the narrow blade inside the nose and the larger blade on the skin outside, grasping the nasal bone between (Fig. 127). Anterior traction and medial rotation are then made, followed by lateral rotation to reposition the fragment (Fig. 128). The quadrilateral cartilage of the septum is now grasped in the Asche forceps and maneuvered into the

groove of the vomer, with the force on the forceps directed upward and anteriorly to elevate the nasal bridge (Fig. 129). Final manipulation is done with the fingers to assure good external contour of the nose. Stabilization of most nasal fractures may be accomplished by an external nasal splint such as the Brown splint. The nasal cavity should be packed bilaterally with ½-inch selvedge edge gauze. Care should be taken that the packing is equal in amount bilaterally to prevent displacement of the septum, and care should be used not to pack the nasal cavity so voluminously as to displace fractured nasal bones outward. If nasal bleeding is not a problem, the gauze may be impregnated with an antibiotic ointment, preferably in a petrolatum-lanolin base. If bleeding from torn septal vessels is a problem, better hemostasis will be secured by using dry plain gauze packing, or one impregnated with an antibiotic powder. Intra-

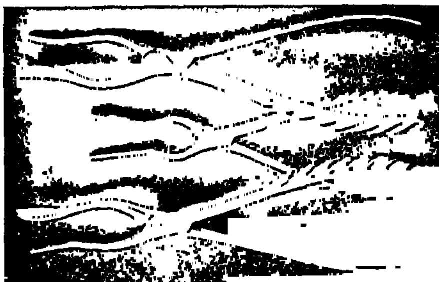


FIGURE 126. Walsham's right and left nasal fracture reduction forceps Asche's septal forceps are shown in the center. (N. L Rowe and H C Killey. Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company.)



FIGURE 127 Method of application of Walsham's forceps to nasal bone (N L Rowe and H C Killey Fractures of the Facial Skeleton Baltimore, Williams & Wilkins Company)



FIGURE 125. The usual displacement of the nasal bones and septum in lateral and anterior nasal fractures. (N. L. Rowe and H C. Killey. Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company.)

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FIGURE 126. Walsham's right and left nasal fracture reduction forceps. Asche's septal forceps are shown in the center. (N. L Rowe and H C Killey. Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company.)



FIGURE 127 Method of application of Walsham's forceps to nasal bone. (N L Rowe and H. C Killey Fractures of the Facial Skeleton Baltimore, Williams & Wilkins Company)

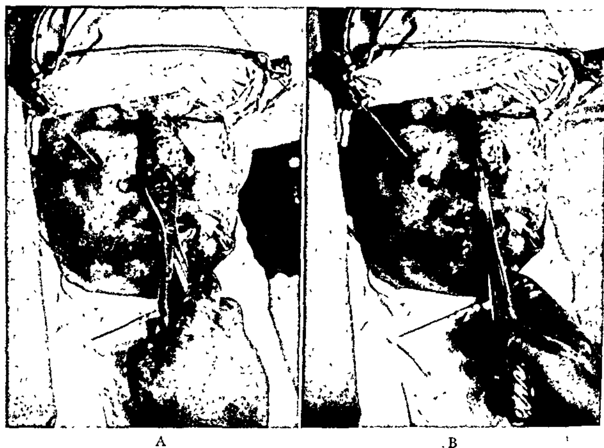


FIGURE 128 *A*, Anterior traction and medial rotation of the nasal bone, using Walsham's forceps *B*, Lateral rotation and anterior traction. (N. L. Rowe and H. C. Killey. Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company)



FIGURE 129. Method of reducing displaced septum with Asche's forceps (N. L. Rowe and H C. Killey: Fractures of the Facial Skeleton Baltimore, Williams & Wilkins Company)

nasal packing is generally left four days, and external nasal splinting is maintained for approximately two weeks.

FRACTURES OF THE ZYGOMATIC BONE

General Considerations

Fracturing in this area is usually due to a direct blow upon the malar eminence, causing downward, inward and posterior displacement of the underlying bone with a hinge movement and separation at the zygomaticofrontal suture. There is also usually a fracture in the infraorbital rim at the junction of the medial two thirds and lateral third with a step-down depression in this area. This fracture usually extends into the infraorbital canal and may contuse the nerve, causing anesthesia of the upper lip. Displacement of the ocular globe may cause diplopia. The malar eminence will be

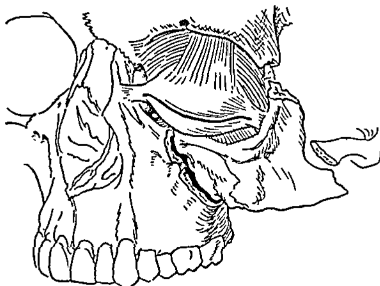


FIGURE 130. Common sites of fracture of the zygomatic bone (N. L. Rowe and H. C. Killey: Fractures of the Facial Skeleton Baltimore, Williams & Wilkins Company.)

lost, and the face will appear flattened (Fig. 130). There also will be variable separation at the zygomaticotemporal suture which may vary from a greenstick type of fracture to complete disruption.

Technique of Reduction

The Gillies method is most universally used (Fig. 131). A small incision is made just within the hairline of the temple and is carried downward to and through the temporal fascia. A substantial elevator as the Gillies modification of Bristow's elevator is then introduced beneath the temporal fascia and pushed downward and forward. The fascia which is attached to the zygomatic bone will carry the elevator beneath the zygoma. A thick gauze roll is then placed under the elevator in the temporal region to protect the soft tissues and to serve as a fulcrum for the elevator, which is then depressed at the handle, causing the end engaged under the zygoma to lift the fractured bone upward, outward and forward. While the elevation is being accomplished, the malar area and the infraorbital rim are palpated to confirm correct reduction.



FIGURE 131. Illustration of the Gillies method of reduction of the fractured zygoma. (N. L. Rowe and H. C. Killey: Fractures of the Facial Skeleton Baltimore, Williams & Wilkins Company.)

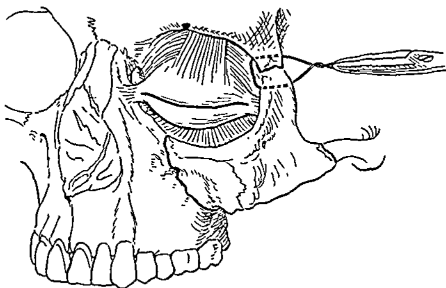


FIGURE 132. Illustration of method of wiring zygomaticofrontal suture separation or fracture. The twisted end of wire should be tucked in the drill hole (N. L. Rowe and H C Killey. Fractures of *the Facial skeleton* Baltimore, Williams & Wilkins Company.)

Most of these fractures will impact upon reduction, and will maintain their position without external fixation if the face is carefully protected from pressure.

Severe displacements may require a combination of Gillies reduction and direct wiring at the zygomaticofrontal suture and at the infraorbital rim, as shown in Figures 132 and 133. Wiring should be accomplished with a very fine wire.

Old fractures in this area which have healed with objectionable facial asymmetry will require open operation, refracture using an osteotome, and reduction by elevation and direct wiring as described above While improvement in the facial contour can be obtained by this method, complete reduction of the fracture and restoration of the facial symmetry are seldom possible and may require camouflage type operations by filling in the depressed defects with diced cartilage or bone.

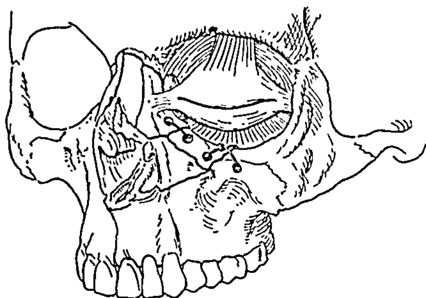


FIGURE 133. Illustration of method of wiring fractures of the infraorbital rim. Very fine wire should be used. (N. L. Rowe and H. C. Killey. Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company.)

FRACTURES OF THE MAXILLARY BONE

General Considerations

These are produced by a direct blow over the maxillary area by some rather small object so that the maxillary bone is fractured into the underlying air cavity of the maxillary sinus (Fig. 134). The amount of deformity produced by this fracture depends to a large extent upon the size of the maxillary sinus. If the maxillary bone is not fully pneumatized, deformity will not be great, and vice versa.

Technique of Reduction

Preferably under general anesthesia with endotracheal tube in place, an incision is made in the canine fossa of the fractured side and carried downward through the mucoperiosteum, exposing the anterolateral face of the maxilla. The mucoperiosteum is then elevated upward, taking care not to injure the infraorbital nerve. By this time fracture lines and spicules of bone will become apparent, and it is through one of these areas that access to the maxillary sinus may be obtained. By using a Kerrison type of punch sufficient bone may be removed to allow surgical access to the maxillary sinus. Old blood is aspirated from the cavity, and the fracture is visualized and then elevated. A valuable instrument for accomplishing this is a curved Kelly hemostat, with a small piece of gauze clamped in the end. Reduction is confirmed by palpation of the face as elevation is being accomplished. These fractures may be supported by a tight gauze packing of the maxillary sinus. One-inch gauze impregnated with an antibiotic powder is to be preferred. Packing is introduced in the superior portion of the sinus cavity and is progressively brought downward as the cavity fills until the trailing end can be brought out the posterior part of the buccal incision (Fig. 135). The incision is then sutured with fine silk Preoperative and postoperative broad-spectrum antibiotic coverage is necessary in these patients. If the patient has no unusual amount of headache or fever, packing should be allowed to remain in place for two to three weeks.

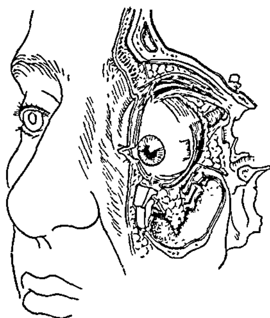


Fig. 134.

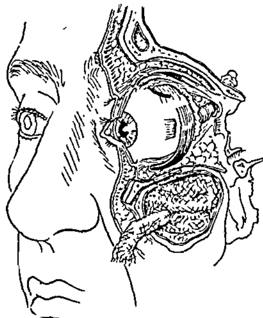


Fig. 135.

FIGURE 134 Diagram illustrating fracture into the maxillary sinus. In this case the floor of the orbit also has been severely comminuted. (N L. Rowe and H. C Killey: Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company.)

FIGURE 135. Reduction of maxillary fracture by the sublabial or Caldwell-Luc approach. The maxillary sinus cavity has been packed with gauze to support the fragments of bone and the trailing end brought out through the incision for later removal (N. L. Rowe and H. C. Killey. Fractures of the Facial Skeleton. Baltimore, Williams & Wilkins Company.)

This will be determined by the amount of comminution of the fracture and to some extent by firmness of the maxilla to palpation. The packing is then removed in one sitting. The remainder of the buccal incision will usually heal secondarily. Occasionally a fistula into the maxillary sinus will result and will have to be closed by undermining the mucosa, freshening the edges and resuturing.

OPERATIONS UPON THE LIPS AND ORAL CAVITY

HARELIP

General Considerations

Operation for harelip is usually indicated in early infancy. The deformity is always distressing to the parents and should be repaired as early as possible. Babies a few days old tolerate the operation well if they are well nourished. Early repair of a cleft lip will minimize lip and nose deformity and aid in molding a coexisting deformity due to a cleft of the alveolar process.

Dangers and Safeguards

The *state of the patient's nutrition* is important. If the child is undernourished, anemic or losing weight, it is good judgment to postpone operation. Any infection producing a systemic reaction is a contraindication to operation. If jaundice develops from the fourth to the tenth day of life, operation is avoided during this time.

Babies and very young children tolerate *hemorrhage* and *shock* very poorly. Pro-

longed operations are more dangerous than in adults. Small transfusions and parenteral administration of liquid are indicated if there is any suspicion that the patient is not reacting well from the operation.

Repair of a harelip is difficult, and results are never perfect. Blair and Brown make the statement that "correction of such defects is more or less simple, but it is a simplicity that is attained only by grinding effort."

Technique of the Mirault-Blair Operation for Single Harelip

Ether anesthesia is used. After induction with a mask, anesthesia is maintained by ether vapor pumped through a tube hooked into the angle of the mouth.

The points *A*, *B*, *C* and *A'*, *B'* and *C'* are pricked on the lip with the point of a knife (Fig. 136). *A* is made in the mucocutaneous border at the base of the columella, *B* in the mucocutaneous border which will join the opposite philtrum, and *C* is placed midway between *A* and *B*. On the opposite side of the cleft, *A'* is placed at the junction of the alar base and the lip with the lip under tension. *C'* is marked below and slightly internal to *A'*. *A'C'* must be equal to *AC*. The incision may be curved outward or angled to make these two distances equal. *B'* is placed on the vermilion border at a distance from *C'* equal to the distance between *B* and *C*.

It is necessary to separate the lip, alae and cheeks from the maxillary bone to bring into proper position both the nose and the short side of the lip (Fig. 136).

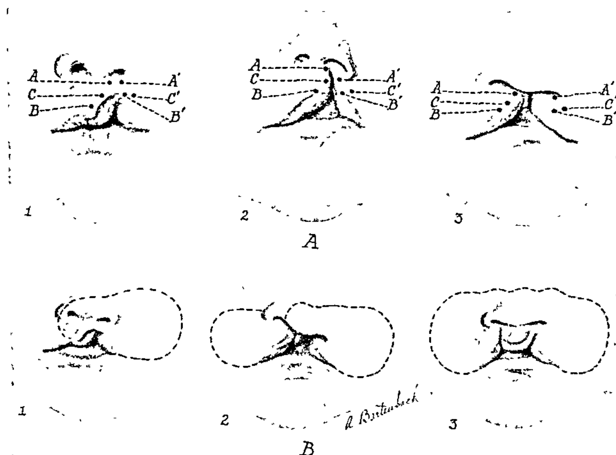


FIGURE 136 *A* *1, 2, 3,* Mirault-Blair operation Dots show locations of incisions in 3 different types *B: 1,* Extent of undermining of soft tissue to relieve tension in repair of partial cleft lip *2,* Undermining necessary for single complete cleft lip. *3,* Undermining necessary for double cleft lip. (Redrawn from Padgett Surgical Diseases of the Mouth and Jaws.)

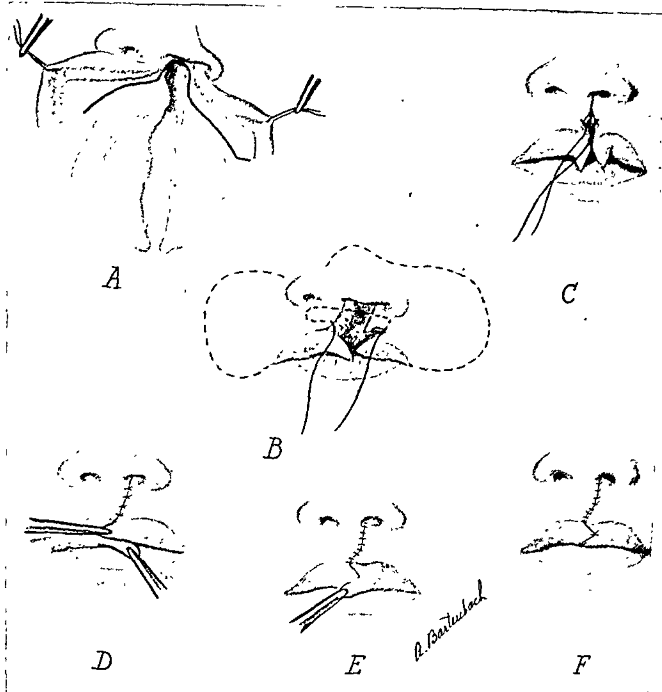


FIGURE 137. Technique of cleft lip repair. *A*, Lines of incision beneath the lip. *B*, Extent of lateral undermining and undermining between skin and cartilage of the nose on the cleft sides Edges of cleft shaped for suturing with deep suture placed. *C*, Edges of cleft approximated with deep sutures *D*, Cross cutting the vermilion border flap to estimate the zigzag incision *E*, Further shaping of the vermilion border incision. *F*, Closure of lip completed. (Redrawn from Padgett: Surgical Diseases of the Mouth and Jaws)

Incisions are made through the lip at the mucocutaneous border as outlined in *ABC* and *A'B'C'*. From *B'* the incision is extended downward and outward to a point about where the upper lip touches the lower (Fig. 137).

An effort to correct the nasal deformity is made before closing the lip. Most of the vestibule lining should be preserved to avoid later obstruction of the nostril. The ala on the cleft side is undermined to a point near the tip of the nose, and a wedge of thickened tissue is cut away subcutaneously. A catgut suture is passed through the tissue at the base of each ala, extending across beneath the base of the columella and

tied to bring the alae into proper position (Fig. 137). The vestibular lining loosened by the undermining along the ala may be held in place with sutures placed through and through the ala and tied on the outer surface. To shape the nostril further, a crescent-shaped piece of tissue may be removed from the upper margin of the nostril

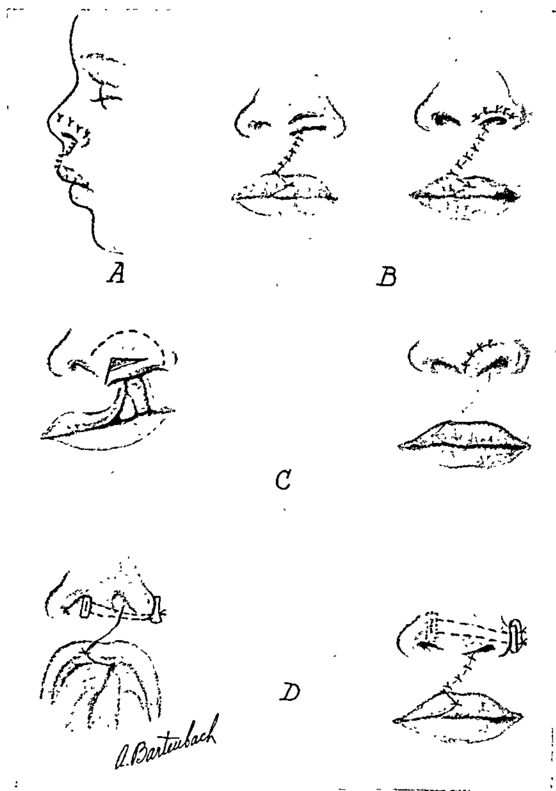


FIGURE 138. *A*, Through-and-through sutures placed to hold internal lining of nostril in proper position *B*, Excision of crescent-shaped section of skin from tip of nostril *C*, Method of splitting columella and raising the lower nostril to a level with the upper nostril. *D*, Method of placing through-and-through retention sutures over tinfoil plate. Inferior and anterior views. (*Redrawn from* Padgett: Surgical Diseases of the Mouth and Jaws)

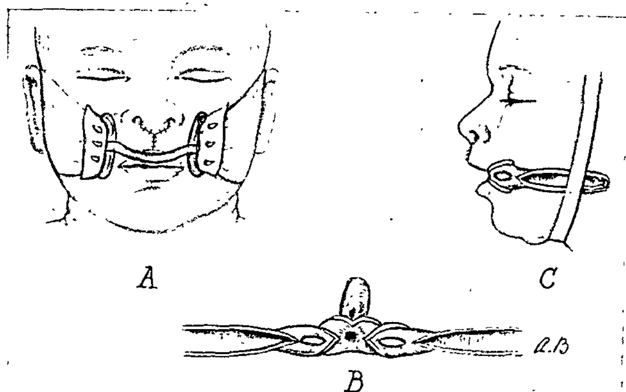


FIGURE 139. *A*, Showing use of Logan clamp for external support of lip to relieve tension *B*, Breathing tube made from rubber tubing. *C*, Rubber breathing tube in place. (Redrawn from Padgett: Surgical Diseases of the Mouth and Jaws)

(Fig. 138). This step is useful in babies. In adults the columella is split, the adjacent mucosa raised from the septum, and the skin undermined over the tip of the nose. The two halves of the columella are sutured together in proper position. The redundant skin along the nostril margin is cut away, and the wound is sutured.

The lip is closed with deep and superficial sutures approximating the points *ABC* with *A'B'C'*. The vermilion border on the long side of the lip is fitted with the Z-shaped cut on the left so that there will be no notch or redundant tab of tissue (Fig. 137). Finally, a nostril retention suture (Fig. 138) is placed from the labial crease of the ala across beneath the floor of the nostril, through the columella. This suture is passed through thin lead plates at each end.

The success of a harelip operation depends much upon the *postoperative care.* If there is much tension, a Logan clamp may be used (Fig. 139). If obstruction to breathing results by sucking in of the lower lip, a tube may be made and placed between the lips as shown in Figure 139.

A dressing for the lip is usually not advisable. The lip is frequently cleansed to remove mouth secretions and prevent the formation of crusts. The nostrils are kept free of discharge. If a gauze pack is used in the nostrils to hold the alar lining in position, it should be removed within three days. If a pack has been placed beneath the undermined cheek to control bleeding, it is removed in forty-eight hours. Skin sutures are removed the fifth day. The sutures beneath the lip are left in place for ten to twelve days.

Early administration of water and food is important. Hypodermoclysis and blood transfusions are used when indicated. If the alveolar ridge is not cleft, nursing may be started in forty-eight hours. If there is an alveolar cleft, the baby should be fed with a spoon or medicine dropper for a week.

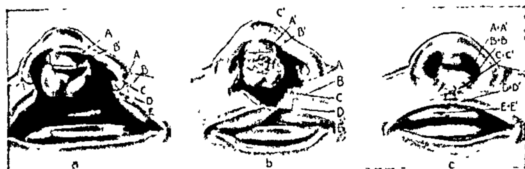


FIGURE 140. Operation for double cleft lip. When the columella is not to be lengthened or is to be lengthened at a subsequent date, the incision on the premaxillary soft tissues and the lip is depicted by the two diagrams *a* and *b*. The appearance of the lip after closure is shown in *c*. (Padgett: Surgical Diseases of the Mouth and Jaws.)

Technique of Repair of Double Harelip

The lines of incision are outlined on the lip and premaxilla, as shown in Figure 140. The margins of the lip clefts and the premaxillary skin are cut away. The closure is made with both deep and superficial stitches in the skin and mucosa. The lettered points *ABCDE* should be accurately sutured to *A'B'C'D'E'*. Padgett warns against making the line *CD* too long and thereby making the sutured lip too long.

Columella lengthening is sometimes advisable. If the projection of the premaxilla is extreme and closure is difficult, lengthening of the columella should be postponed. If the anterior palate and lip are repaired at the same time, it is better to postpone operation upon the columella.

To lengthen the columella, all the soft tissues are loosened from the premaxillary process, and the cartilage of the septum is exposed. The skin of the old columella with its cartilage is cut upward toward the tip of the nose, and the premaxillary soft tissues are advanced toward the tip of the nose and refashioned into a columella of the required length. Excess skin and subcutaneous tissue are cut away.

The plastic procedures on the alae and repair of the vermilion border are similar to those used in the Mirault-Blair technique for repair of a single cleft lip.

If the condition of the patient will permit, the anterior palate may be repaired at the same time the lip is closed. To replace a protruding premaxilla properly, it may be necessary to fracture or cut a V-shaped section from the septum. Under no conditions should the premaxilla be removed. Excessive compression of the premaxilla should also be avoided. After a successful lip repair the premaxilla will assume a fairly normal position within seven to eight months.

Through-and-through double sutures are introduced from one alar sulcus to the other, placed through perforated thin plates of lead foil. The nostrils are packed with gauze for two days.

The postoperative care does not differ essentially from that outlined above for single cleft repair.

CLEFT PALATE

General Considerations

The indications for operation are definite. A child with palatal cleft has difficulty with sucking, swallowing and phonation. Pharyngeal and middle ear infections are common. Such children are likely to be undernourished because of feeding difficulties.

Blair has considered the optimum time for palate operation about twelve to fourteen months of age if the child is in good physical condition. This general plan is followed by Padgett. He believes that with careful selection of cases, use of blood transfusions and intravenous therapy, combined with experience and manual dexterity, patients may be operated upon under one year of age with a minimum mortality. It is probable that function of the soft palate muscles and phonation are improved by early repair.

Dangers and Safeguards

The *state of nutrition* of the patient at the time of operation is of great importance. Careful feeding is necessary for several months before the operation. Anemia adds greatly to the operative risk. When anemia exists, it is better to postpone operation until it is successfully treated.

Operation is positively contraindicated if there is any evidence of *nasopharyngeal infection.* Serious illness and failure of wound healing are often the results of operation in the presence of infection, either local or general.

Loss of blood with shock is probably the most important immediate danger of palate operations. Children tolerate bleeding very poorly. Blood for transfusions should always be available. By the careful use of suction, aspiration of blood or mucus is prevented. This minimizes the danger of postoperative pneumonia.

For a proper understanding of the steps of a cleft palate operation, a knowledge of the anatomy of the part is necessary. It is particularly essential that the blood supply to the palate be known (Fig. 141). Every surgeon will have a certain percentage of

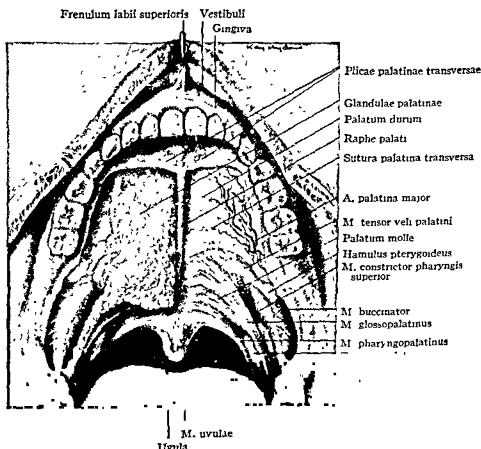


FIGURE 141 Superficial and deep structures of palate and tonsil regions (Callander Surgical Anatomy)

operative failures or partial failures. With experience, 80 to 90 per cent of primary closures may be expected.

With proper selection of cases, careful preoperative preparation and operative technique, the mortality rate should not exceed 3 to 4 per cent. In a series of 126 cases Padgett reports a mortality rate of 3.1 per cent.

Technique of the Dieffenbach-von Langenbeck Operation for Cleft Palate

Ether anesthesia is used. After primary induction with a mask, ether vapor is administered through a tube. The Rose position with the patient's head extending over the end of the operating table resting on the operator's knees is preferred. A few special instruments are used, such as a Lane gag, Brophy elevator and modified Fergusson elevator (Fig. 142). A suction tip to remove blood and secretions is much more efficient than gauze sponges.

The various steps in the operation are illustrated in Figure 143 (Padgett). An incision is made on each side through the mucoperiosteum down to the bone, beginning opposite the cuspid tooth just medial to the alveolar ridge and extending backward and outward to a point outside the hamular process almost to the anterior pillar of the tonsil. Through this incision the mucoperiosteum is dissected up with an elevator of the Fergusson type inserted both in front and behind the posterior palatine artery and nerve. The artery and nerve must be preserved. The palatine artery is easily torn where it passes through its foramen and turns forward to supply the hard palate.

The margins of the cleft are trimmed off with scissors or knife. Beneath the median margin a Brophy elevator is inserted, and the loosening of the palatal flap from the bone is continued. When the flap is separated, it is turned up with a hook or needle, and the soft palate is separated completely from the posterior ledge of the palatal bone. If sufficient relaxation is not obtained by these steps for easily approximating

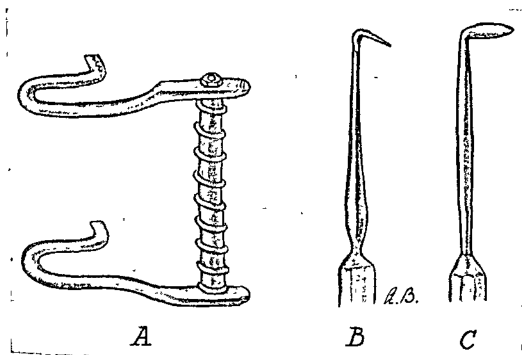


FIGURE 142. *A*, Lane gag *B*, Brophy elevator. *C*, Modified Fergusson elevator.

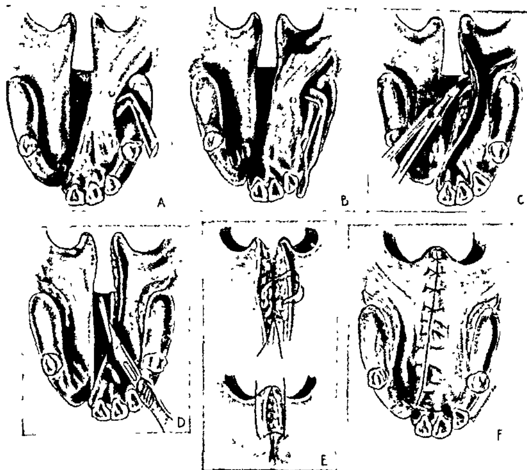


FIGURE 143. Dieffenbach-von Langenbeck operation with lateral incisions. *A*, Method of using the elevator to raise the mucoperiosteal flaps of the hard palate from the horizontal plates of the palatal bone. The elevator is first inserted anterior to the palatine artery, which one recognizes by the dimple as shown in the diagram. *B*, The elevator next is inserted posterior to the palatine artery. *C*, Then the raphe on the upper surface of the palate between the hard and soft palates is cut. *D*, A pack is placed in the lateral incisions to prevent bleeding while the medial edge is being pared. The soft palate is split at the medial edge so that one may suture the upper mucosal surface to the opposite side separately from the lower mucosal surface. The edges of the hard palate are pared so that an even, raw surface is given on either side *E*, The first suture taken is in the firm, soft tissues of the raphe in such a manner that the knot falls upon the upper surface of the palate. Such sutures may be taken in the raphe to draw the palate together. When one comes to the uvula, it is pulled forward by a suture placed so that one may take interrupted sutures on the upper surface of the palate back midway of the soft palate Some cases may have some tension when the soft palate is brought together in the midline. One may clip the posterior pillars to gain relaxation if necessary. *F*, A double whipping suture which coapts the superficial and the deep tissues of the soft palate is used to bring muscle layer to muscle layer. Interrupted vertical mattress sutures are then taken in the hard palate up to the incisor region This completes the routine Dieffenbach-von Langenbeck operation (Padgett: Surgical Diseases of the Mouth and Jaws)

the flaps in the midline, the mucosa and muscles of the nasopharynx above the soft palate are relaxed by cutting outward, upward and backward toward the eustachian tube opening. If further relaxation is needed, the hamular process may be fractured with a small chisel. When the dissection is completed on each side, gauze is packed into the lateral incision both anterior and posterior to the artery to control bleeding and hold the flap in a medial position.

When the nasal septum is attached to one side of the hard palate, about 0.5 cm. of the mucosa covering the septum may be raised with one palatal flap.

The first suture is placed through the upper tissues of the palate so that the knot will lie on the nasal side. Two silk sutures of this type draw the median raphe together.

Horsehair is used for the remaining sutures. The uvula is sutured on both oral and nasal sides. Vertical mattress sutures are used and so placed that the raw surfaces of the wound edges are approximated a distance of 2 to 3 mm. Sutures are tied with just enough tension to close the wound. Excessive tension will cause sloughing and failure.

At the end of the operation the gauze packs in the lateral incision are removed and replaced. The packs are made just large enough to fill these wounds. If too large, they will interfere with breathing. They should be renewed in two to four days.

The patient must be carefully watched after operation. While he is recovering from the anesthetic, bleeding can be more readily detected if the child is placed on his side with the foot of the bed raised. Any evidence of shock is treated immediately with heat, infusion and transfusion. A child may die of shock before its serious condition is realized, unless watched by an experienced nurse.

Fluids are given by mouth with a spoon or medicine dropper as soon as the patient recovers from the anesthetic. The diet should consist of liquid foods for the first three weeks. The nose is kept free of discharge by careful cleansing with cotton swabs and irrigations of saline solution.

Technique of Brown's Modification of the Dorrance Push-Back Operation

This operation has been designed to elongate the soft palate so that it will meet the posterior wall of the pharynx to close the opening between the nose and throat by a sphincter-like muscle action. It is especially suited for partial clefts of the palate which have abnormally short palates. In this group the bony palate is present to separate the nose from the mouth.

First Stage of Operation (Figs. 144, 145, *A*). An incision is made along the inner border of the alveolus backward on each side over the anterior pillar. With an elevator the mucoperiosteum is detached completely from the bone. The arteries are carefully

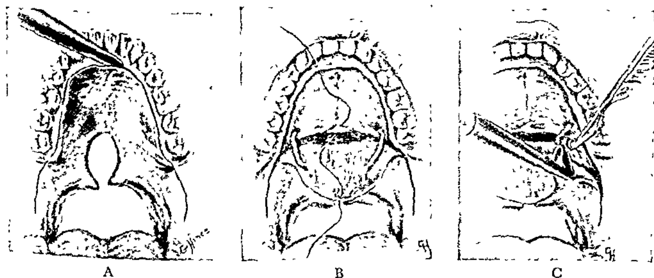


FIGURE 144. Technique of elongation of palate *A*, Line of incision and beginning elevation of periosteum *B*, Palate completely detached from bone Both major palatine arteries intact. Band of nasal mucosa preserved to which the palate is attached with the first suture. *C*, Detail diagram of deep separation of the soft tissues. Exposure of the hamulus, freeing of the palate aponeurosis in this area behind the artery, and section of the tensor tendon. (Brown· Surg., Gynec. & Obst , Vol. 63. By permission of Surgery, Gynecology and Obstetrics)

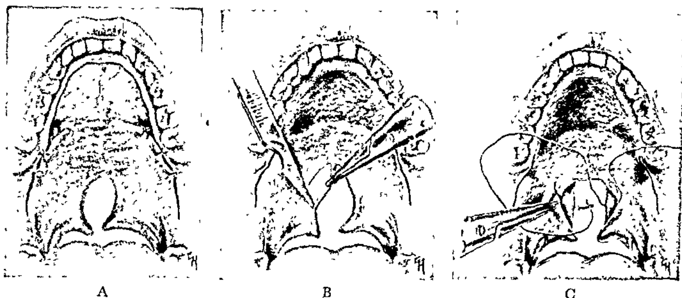


FIGURE 145. Technique of elongation of palate (*continued*). *A*, Completion of first stage. The palate has been set back and anchored with horsehair sutures. *B*, Beginning of second stage; new openings through the former lateral incisions may or may not be thought necessary. The edge is trimmed from the tip of the uvula up into the palate substance about 2 mm *C*, A deep stay suture is placed to engage a good bulk of tissue Extra muscle and nasal mucosa sutures may be put in at this stage. (Brown. Surg , Gynec. & Obst., Vol. 63. By permission of Surgery, Gynecology and Obstetrics)

preserved. When the posterior margin of the palate is reached, the nasal mucosa is opened. A narrow strip of mucosa is left attached to the bone to be used later for anchoring sutures. The space behind the arteries down to the hamulus and pterygoid plate is opened to mobilize all soft tissues the full length of the incision. The tensor muscle and aponeurosis are divided at the hamulus. The arteries are carefully elongated by stretching them from the foramina and by separating them from the raw surface of the palate.

After completion of dissection the anterior cut edge of the mucoperiosteum flap

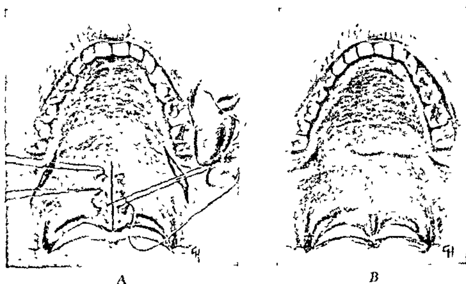


FIGURE 146 Technique of elongation of palate (*continued*) *A*, Closure of cleft in soft palate with vertical mattress sutures The closure is carried completely around the uvula and on to the nasal surface, using fine chromic catgut sutures *B*, Technique of elongation of palate (*concluded*). Appearance after complete healing (Brown Surg , Gynec & Obst , Vol 63 By permission of Surgery, Gynecology and Obstetrics)

is sutured to the posterior margin of the bony palate with sutures. The lateral margin of the flap is sutured to the maxillary tubercle on each side.

The denuded bony palate is covered with a pack of balsam of Peru and iodoform gauze. This pack is removed about the sixth day. Complete healing of the raw area will occur in twenty to thirty days.

Second Stage of Operation (Figs. 145, *B*, *C*; 146). The edges of the cleft in the soft palate are freshened by cutting away the marginal mucosa and suturing. If necessary, lateral relaxing incisions may be made. If the general condition of the patient is good, this stage may be combined with the first-stage operation.

RESECTIONS OF THE MAXILLA

Resections of the upper jaw are usually done for malignant tumors. Occasionally it is advisable to remove a portion of the upper jaw with a benign tumor.

Dangers and Safeguards

Complete excision of the upper jaw is an extensive and mutilating operation. Bleeding is often profuse, and shock is likely to occur. Matas has recommended preliminary ligation of the external carotid artery to reduce bleeding.

Infection is always present and produces a foul, ulcerating wound after operation. Pneumonia is a complication to be anticipated, particularly in the aged. After healing there is considerable disfigurement and disturbance of the function of mastication. On the whole, excision of the upper jaw for malignant tumors has not been satisfactory. The use of radium and the cautery is frequently more desirable and causes less immediate danger to life than resection.

Technique of Resection of Superior Alveolar Process (Padgett)

If teeth are present before or behind the section to be removed, they are extracted. Incisions are made through mucosa and periosteum to the bone on the buccal and lingual sides, outlining the bone to be resected. At each end of the portion to be removed the alveolar process is cut across with a thin chisel or osteotome. A horizontal cut is made through the bone along the lines of the mucoperiosteal incisions, and the section of the alveolar process is removed with bone forceps. Bleeding is often profuse. It can usually be controlled by pressure and by suturing the mucosa of the cheek over the bone to the palate mucosa.

Technique of Resection of Maxilla (Fig. 147)

High ligation of the external carotid is recommended by Matas to reduce bleeding. The skin incision of Weber is satisfactory. This incision begins below the inner end of the lower eyelid and extends downward along the nose and around the ala to the midline of the upper lip. A second incision is made extending outward from the first incision along the lower margin of the orbit. These incisions are carried to the bone, and a cheek flap as outlined is reflected outward to the malar bone.

The periosteum covering the floor of the orbit is separated, and the orbital contents are retracted upward. The malar bone is next divided with bone forceps or a Gigli saw. The nasal and orbital processes are divided in the same way. The muco-

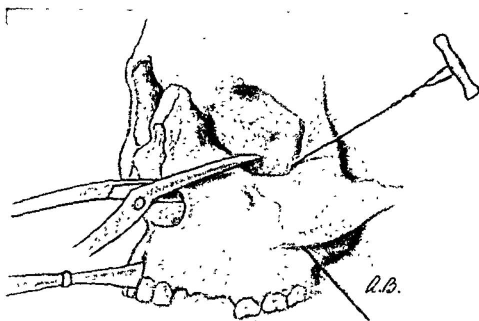


FIGURE 147. Technique of excision of upper jaw. A chisel is used to separate the maxillae in the midline. The superior process is cut with bone forceps, and the malar process is divided with a Gigli saw. (Redrawn from Padgett: Surgical Diseases of the Mouth and Jaws.)

periosteum is incised with a knife near the midline back to the soft palate. The hard palate and alveolus are divided with chisel, forceps or finger saw. The soft palate on the side being resected is separated with scissors. With heavy bone-holding forceps, the maxilla is removed with a twisting motion. Any adherent tissue is divided with scissors. Bleeding vessels are clamped and ligated. There is usually much oozing, which is controlled with a gauze pack. The cheek wound is closed over the pack with interrupted silk sutures.

The after-care is important, since danger of pneumonia is great. The patient should lie in bed on the side operated upon. The sitting posture is advised as soon as the patient's condition will permit. The mouth is kept clean by frequent irrigation and mouth washes. After healing, a proper denture should be fitted. The best results are obtained by a plastic procedure to reline the cheek with epithelium.

OPERATIONS UPON THE MANDIBLE

General Considerations

The more common surgical procedures upon the mandible are (1) open reduction for fracture; (2) lengthening of the mandible for micrognathism; (3) shortening of the mandible for prognathism; and (4) partial or complete resection for neoplastic disease arising in or adjacent to it. The first three of these procedures require a detailed knowledge of dental anatomy, the ability to apply arch bars and do interdental wiring and, in the operations for micrognathism and prognathism, the ability to make impressions of the mouth and plaster study models to measure precisely the amount of lengthening or shortening of the mandible required. More properly, these operations belong in the domain of the oral surgeon and will not be considered further here.

Primary carcinoma of the gingiva has only to penetrate the periosteum to gain

entrance to the bone. Tumor cells spread by way of the haversian canals with relative ease, so that involvement of bone is always greater than is apparent on the x-ray films. This fact must always be taken into consideration in planning the excision of the primary carcinoma in order that ample margin, at least 2 cm. from the visible periphery of the growth, will be obtained. Once the tumor has extended into the inferior dental canal, malignant cells may be present from the mental foramen to the mandibular foramen, and complete hemisection of the mandible from the symphysis anteriorly to disarticulation of the joint posteriorly is indicated. Soft tissues, except skin, overlying the mental foramen should also be removed attached to the mandible. The chief cause of failure of this operation is inadequate resection.

Extramandibular metastatic masses, such as metastases into the submaxillary and sublingual lymph nodes from carcinoma of the lip, which involve the periosteum of the mandible must be treated as though they had arisen in the alveolus primarily. To strip these masses off the mandible will only leave behind tumor cells already firmly entrenched in the mandibular bone and will account for the failure of the operation. The rich lymphatic bed in which these tumors lie makes a complete homolateral neck dissection at the time of primary resection mandatory.

Dangers and Safeguards

The chief danger in these operations, as noted above, is inadequate margin of excision and postoperative continuation of the tumor. The field is a highly vascular one, and bleeding will be troublesome and will require on-the-table transfusion of whole blood. Bleeding from the jaw area can be lessened by early ligation of the external carotid artery.

Removal of a section of the mandible creates a serious problem in management of the remaining fragments. These may be stabilized by drilling a Kirschner wire into the fragments, as will be described under technique.

Partial removal to complete hemisection of the mandible results in the loss of support of the soft tissues of the floor of the mouth, the tongue and the homolateral pharyngeal wall, so that these tissues will tend to fall into the pharynx and hypopharynx and cause varying degrees of respiratory obstruction. Some type of wire support of the tissues previously supported by the resected mandible or tracheostomy will alleviate this condition. At the termination of the procedure, if there is the slightest doubt about the adequacy of pharyngeal airways, a tracheostomy should be done. Some difficulty in closing the floor of the mouth may be encountered if, because of the size of the primary tumor, the resection has been extensive. Judicious undermining of tissues, especially bucally, so that closure without tension can be attained is necessary for the prevention of an oral fistula.

Infection is minimized by having the oral cavity as "clean" preoperatively as possible by appropriate dental therapy and by the preoperative and postoperative use of broad-spectrum antibiotics To prevent trauma to and stress on the suture lines, postoperative nutrition is maintained through a nasogastric feeding tube.

Technique of Resection of the Mandible

General anesthesia with a nasal-tracheal tube is used. The extent of the mandibular resection governs the type of incision. If only a section of mandible is to be

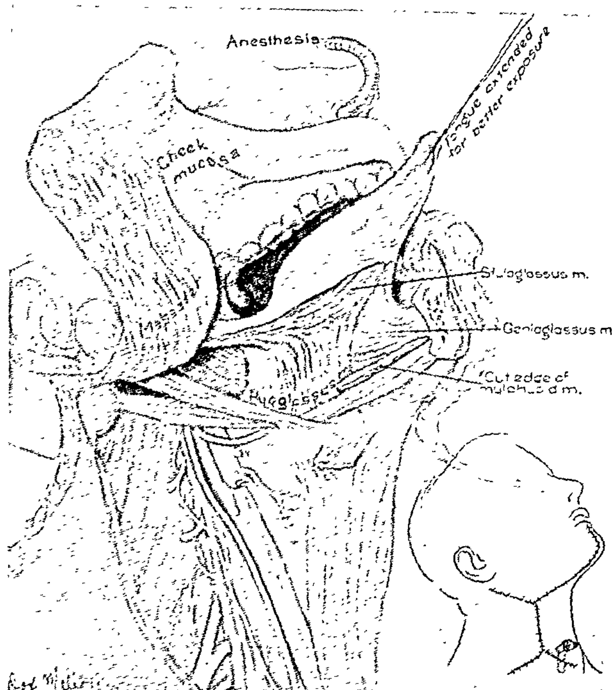


FIGURE 148 Resection of half the mandible combined with unilateral neck dissection for control of primary carcinoma and its lymphatic spread Inset shows type of incision used and closure. (M. M. Copeland Ann Surg., Vol 141)

removed, an incision from the mastoid process to the mental foramen 2 to 3 cm. below and parallel with the lower border of the mandible is made, with a vertical incision dropping downward from the middle of this to the supraclavicular area. Further access to the trachea for tracheostomy or the supraclavicular area can be had through incisions as indicated in the inset of Figure 148. If the mandible is to be hemisected, the lip-splitting type of incision as shown in the inset of Figure 148 will give the best exposure. Flaps including the platysma muscle are raised. The neck dissection is started first from below upward to the bifurcation of the carotid, as described elsewhere in this chapter. The external carotid is ligated in continuity Attention is now directed to the oral cavity.

If only a section of mandible is to be removed, the mouth is held open with a

gag. The mucous membrane is incised around the lesion, allowing 2 to 3 cm. margin. The incision is deepened bucally and lingually on each side of the mandible with a scissors until there is through-and-through communication with the submaxillary region, which has already been partially exposed by the neck dissection. The periosteum is then cut through in the two areas where the mandible is to be sectioned and is elevated for a short distance. A Gigli saw is now passed around the mandible from below and the mandible sectioned. The resected mandible with the primary tumor is now pulled down into the neck. Submaxillary dissection is completed downward into the neck to join the dissection from below. Dissection is now completed posteriorly and superiorly, ligating the internal jugular vein at the base of the skull and excising the surgical specimen by detaching the sternocleidomastoid muscle from the mastoid process.

Repair of the oromandibular defect consists first in drilling a Kirschner wire into the ends of the sectioned mandible, using the wire to bridge the bony defect, after the mandible has been adjusted to its original position in relation to the upper jaw. This relationship is most easily established when teeth are present which can be put in occlusion. The Kirschner wire may be driven into the inferior dental canal. If this is done, the wire must be large enough to fit tightly. The mucosa of the mouth is closed interruptedly, using fine silk or catgut and taking care to get a watertight closure. The neck wound is thoroughly irrigated with sterile saline solution. Tracheostomy is done if deemed necessary. The neck is closed with drainage as described elsewhere in this chapter. A nasogastric feeding tube is passed, and sterile dressings are applied to the neck with moderate pressure to ensure application of the flaps to underlying structures.

When complete hemisection of the mandible is to be done, the initial incision includes the midline lip-split as shown in the inset of Figure 148. The neck dissection is completed from below upward to the bifurcation of the carotid, and the external carotid is ligated. The lateral soft tissues are then completely freed from the mandible by cutting through the buccal sulcus, staying 2 to 3 cm. away from the tumor. These tissues are reflected laterally from the mandible. In reflecting the tissues from the ramus laterally, one must stay close to the periosteum to prevent injury to the overlying parotid gland and facial nerve, and in this area medially, staying close to the periosteum will minimize the bleeding. The soft tissues are now cut circumferentially from the mandible at the symphysis, after which the Gigli saw is passed around the bone, and the mandible sectioned. The mandible is now freed from the floor of the mouth by cutting the attachments of the genioglossus and mylohyoid muscles, carrying the excision posteriorly and superiorly along the ramus. When the temporomandibular joint is reached, the capsule is incised and the mandible disarticulated. The mandible and its attached soft tissues are now brought down into the neck, and the neck dissection is completed as described above. With the mandible removed and the neck dissected, the surgical field will appear as in Figure 148. An attempt may be made to prevent drift of the opposite mandible to the resected side by drilling a threaded Kirschner wire into the mastoid process and then bending the wire to conform to the resected bone and driving the remaining end into the cut end of the opposite mandible. The wire should be strong enough to hold the opposite mandible over and the tongue forward, yet springy enough to allow some opening and closing

of the mouth for a few week, after which it may be removed. Special prostheses with a ball end to fit in the glenoid fossa may be obtained for stabilization of the opposite mandible. The mouth and lip are now carefully sutured interruptedly and the operation completed as described for a limited resection.

Postoperative Care. If no tracheostomy has been done, the patient must be watched carefully for respiratory obstruction. The mouth and pharynx are kept free of secretions by careful aspiration. If a tracheostomy has been done, it is suctioned as required. Preoperative antibiotics are continued postoperatively. A high-caloric liquid feeding is begun through the nasogastric tube on the first postoperative day and is continued until the mouth is healed. Patients frequently will be able to eat soft foods by the tenth postoperative day. Drains are removed when they have served their purpose, usually from the third to fifth postoperative day. The tracheostomy tube, if present, is removed when the patient can breathe well with the tube corked.

The Kirschner wires can be removed any time after a few weeks if they cause irritation, since usually enough scar will have formed to stabilize the fragments. Defects from a partial resection may be repaired later by bone graft if desired. The prosthodontist can often make half of a lower denture to fit the unresected mandible, and this will articulate sufficiently well with upper teeth or dentures to be of considerable aid in mastication.

OPERATIONS UPON THE LIPS

General Considerations

There is a difference of opinion concerning the relative merits of irradiation and operative therapy for carcinoma of the lip. Except for extensive growths of doubtful operability, it is probably better therapy to excise the primary lesion and follow this by excision of the regional lymph nodes. Extensive lesions destroyed by irradiation may be amenable to plastic repair when healing is complete.

Small lesions of the lip may be removed by a simple V-shaped incision. More extensive involvement of the lip requires excision and plastic repair as shown below. Carcinomas of the upper lip are removed by a technique similar to that used for the lower lip.

Technique of V-Shaped Excision (Fig. 149)

Local anesthesia may be used. An incision is made through the entire thickness of the lip 0.75 to 1 cm. beyond the margins of the growth. The two incisions extend to the chin margin. The coronary artery is ligated on each side with fine catgut.

The wound is closed with interrupted sutures. On the mucosal side, silk sutures are placed deeply to approximate most of the thickness of the lip The skin is closed with fine silk or horsehair. Careful approximation of the vermilion border is essential for good cosmetic results.

Technique of V-Shaped Excision with Use of Flap from Upper Lip (Padgett) (Fig. 149)

If one third to one half of the lower lip is removed from the angle of the mouth medially, a flap from the upper lip may be turned down to f efect.

A triangular flap similar to the section of lip removed below, but about half as large, is cut through the full thickness of the upper lip. About 5 mm. of the lip margin containing the coronary artery are left intact as a pedicle. The section of mucosa should be somewhat larger than the skin area to easily close the mucosal defect of the

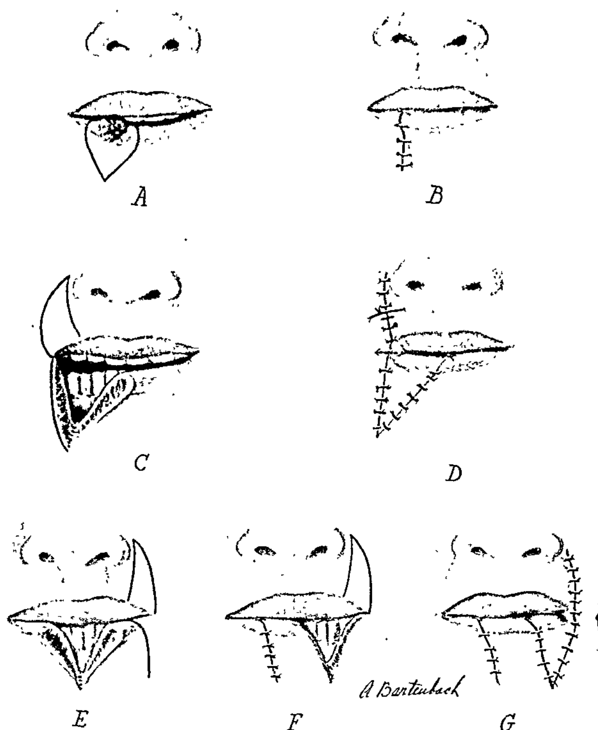


FIGURE 149. *A*, Incisions for removal of v-shaped section of lip *B*, Lip sutured after removal of v-shaped section. *C*, Excision of v-shaped section of one third to one half of lower lip. Upper lip flap outlined *D*, Upper lip flap sutured into defect of lower lip. *E*, One half of lower lip excised. Outlines of upper and lower lip flaps. *F*, Left position of lower lip shifted to form central portion of lip. *G*, Upper lip flap sutured into defect of left lower lip (Redrawn from Padgett Surgical Diseases of the Mouth and Jaws)

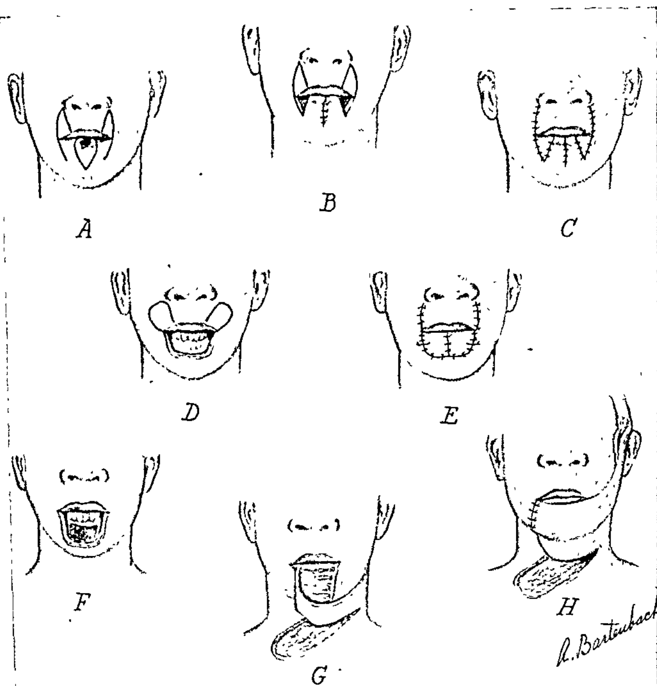


FIGURE 150. Method of repairing lower lip after three fourths of the lip has been excised. *A*, Lower lip shows outline of tissue excised Two upper lip flaps are outlined *B*, Edges of lower lip defect have been united in the midline *C*, Upper lip flaps have been sutured in place to rebuild lower lip.

Method of repairing almost total loss of lower lip *D*, Flaps outlined on the upper lip and cheeks. *E*, Upper lip and cheek flaps turned down to fill the lower lip defect. Cheeks and upper lip sutured

Rebuilding a lower lip after its complete removal *F*, Lower lip completely removed down to bone. *G*, Neck flap fitted into lip defect with raw surface outward This is used to line flap from scalp *H*, Scalp flap sutured in place over neck flap. (Redrawn from Padgett Surgical Diseases of Mouth and Jaws.)

Technique of Excision of Wedge-Shaped Portion of the Tongue (Fig. 151)

Local or general anesthesia may be used. To control the tongue, a strong silk thread is passed through the tongue near the tip. A through-and-through suture is placed beyond the line of incision so that the wound may be quickly closed to control bleeding. A wedge-shaped portion of tongue is removed with knife or scissors. A sufficient number of silk sutures are placed to control bleeding and close the wound.

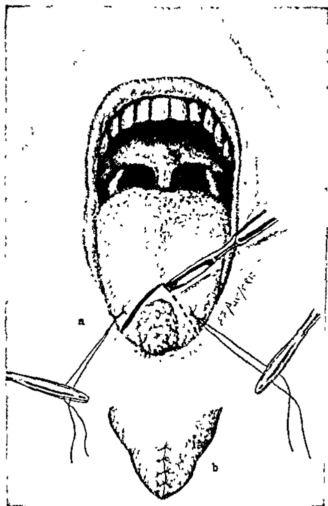


FIGURE 151. Removal of small growth from tip or side of tongue. Tension sutures are placed before the wedge-shaped portion is excised. Through-and-through interrupted sutures are placed to close the defect. (Bickham: Operative Surgery, Vol. III.)

Technique of Excision of Longitudinal Half of Tongue (Blair) (Figs. 152, 153)

The operation may be advantageously done with the patient in the Rose position. The mouth is held open with a gag, and the tongue is controlled by a transfixing suture of silk.

The tongue is split in the midline back to the frenum. From this point backward the halves may be separated by blunt dissection. Division is carried back as far as the line of proposed excision, forward to the mandible and downward to the inferior borders of the geniohyoglossus muscle. The mucous membrane of the floor of the mouth is divided well beyond the margin of the tumor. The submaxillary duct should be avoided unless the gland is removed. The sublingual and submaxillary glands may be removed if involved The tissues of the floor of the mouth are separated, exposing the geniohyoglossus muscle backward from the genial tubercle. The lingual nerve is severed and the lingual vein ligated.

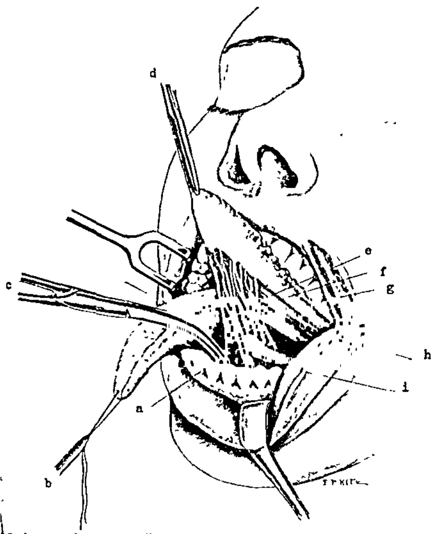


FIGURE 152. Excision of half of the tongue by the Blair technique The tongue is split in the midline, and the mucosa of the floor of the mouth is incised to expose the vessels, nerves and muscles *a*, Ranine vein; *b*, tractor in retained half ... glossus; *d*, tractor on half of tongue to be excised; *e*, lingual ... divided hyoglossus muscle; *i*, hyoglossus nerve. (Bickham ...

The half of the tongue to be removed is pulled forward and upward, and the geniohyoglossus muscle is divided near the genial tubercle. As the dissection proceeds backward, the lingual artery near the midline is identified, cut and ligated. The half of the tongue to be removed is then cut across. The dorsal artery and other smaller vessels are ligated. Mattress sutures aid in the control of bleeding.

The traction suture in the preserved half of the tongue is left in place until the patient recovers from the anesthetic.

Technique of Removal of Tongue with Floor of Mouth (Figs. 154, 155, 156, 157)

Moderately extensive neoplastic lesions involving the tongue and contiguous floor of the mouth may be removed by this technique and combined with an en bloc dissection of the neck. If there is no spread of neoplasm to near the mandible, it may be preserved. Neoplasms in this area are intimately associated with abundant lymphatics, so that for all practical purposes a neck dissection should accompany the excision of the primary lesion.

Before operation the mouth should be rendered as free of septic processes as possible by appropriate dental treatment, and for about three days before operation broad-spectrum antibiotic therapy should be instituted.

A lip-splitting incision as illustrated in the inset of Figure 154 is constructed and the skin flap including the platysma muscle raised. The classic lateral neck dissection as described subsequently is started from below and carried to the bifurcation of the carotid artery. Ligation of the external carotid artery at this point will considerably reduce the bleeding in the mouth and tongue area to be attacked next (Fig. 154).

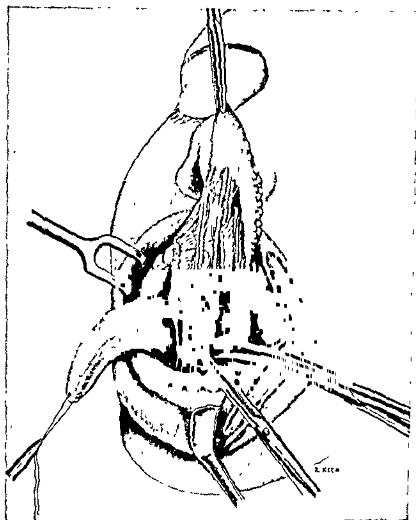


FIGURE 153 Excision of half of the tongue by the Blair technique (*continued*) The tongue is divided at its base, muscles are severed, and vessels are divided and ligated (Bickham Operative Surgery, Vol III)

The mandible is now transected at the symphysis with a Gigli saw, and the mucosal incision circumscribing the lesion is outlined (Fig. 155). The tongue is now hemisectioned, and the tissues of the floor of the mouth are cut away from their mandibular attachments and dissected downward into the submaxillary triangle to join the lateral neck dissection, as illustrated in Figure 156. The neck dissection is now continued posteriorly and superiorly until detachment of the sternocleidomastoid muscle from the mastoid process effects the removal of the specimen. Closure is now effected, as diagrammed in Figure 157. The mandible is reapproximated in the midline by stain-

less steel wires through small drill holes. The mucosa of the floor of the mouth may be approximated with either absorbable or nonabsorbable suture, the former to be preferred, since removal of nonabsorbable material in this area is rather difficult. Upon completion of the procedure a low tracheostomy is done to relieve the upper respiratory obstruction which almost surely will follow, owing to edema of the tissues, and to permit aspiration of lower respiratory tract secretions which would be difficult for the patient to cough out. A nasogastric feeding tube is passed and the patient maintained

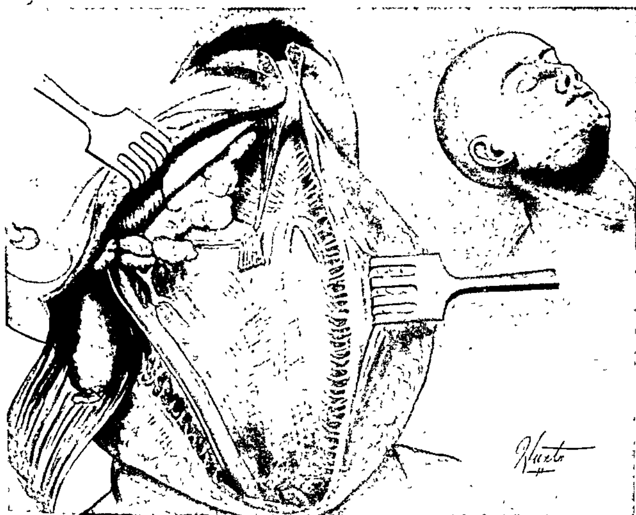


FIGURE 154 Inset, right upper corner, illustrates the skin incision The lateral neck dissection has been begun; the sternocleidomastoid muscle has been detached from the sternum and clavicle, the internal jugular vein has been ligated at the level of the clavicle These structures with the supraclavicular fat pad have been dissected to the bifurcation of the carotid, and the external carotid has been ligated in continuity (A J Kremen Surgery, Vol 30)

on tube feedings. Antibiotics begun preoperatively are continued postoperatively until healing is complete.

The tracheostomy tube may be removed when the patient can breathe easily with the tube corked. This type of operation obliterates the lingual sulcus and makes the fabrication of a good-fitting lower denture impossible; however, the prosthodontist may be able to make a half-denture which will function satisfactorily. Tongue movements are severely impaired, and this will cause some difficulty in swallowing and considerably more difficulty in the production of understandable speech.

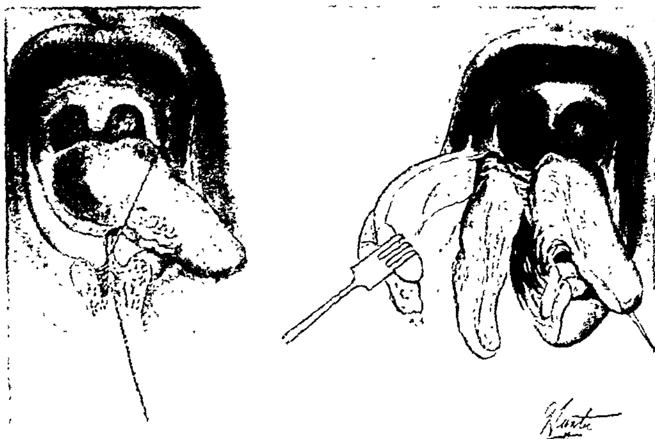


FIGURE 155.

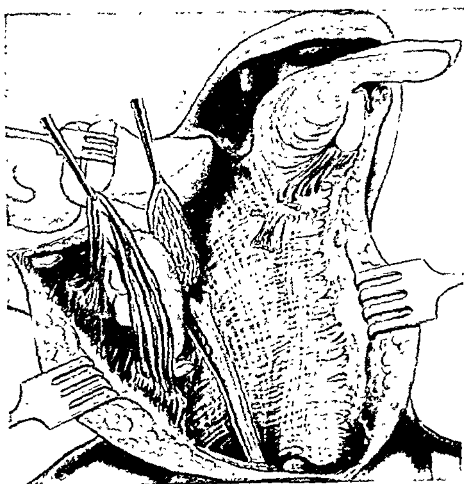


FIGURE 156

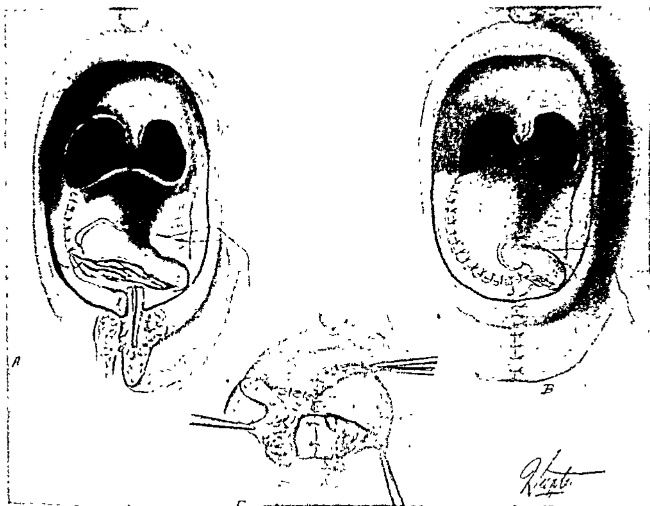


FIGURE 157. Reconstruction of the oral cavity. The dorsal mucosa of the tongue is sutured interruptedly to the mucosa of the alveolar ridge after bringing the mandible back to its normal position and wiring it to the opposite side. Undermining of glossal tissues may be necessary to permit closure. *B,* The tip of the tongue is being reconstructed by suturing the mucosa of the inferior aspect to that of the superior aspect. *C,* The method of wiring the mandible into position. (A. J. Kremen: Surgery, Vol. 30.)

OPERATIONS UPON THE TONSILS AND ADENOIDS

PERITONSILLAR ABSCESS

General Considerations

Peritonsillar abscess results from an infection in a tonsillar crypt which extends to the capsule of the tonsil. The crypt becomes plugged with inflammatory debris, and the infection then burrows into capsular space, forming an abscess. Looseness of tissue at the superior tonsillar pole favors formation of abscess in this area. Treatment is by incision and drainage.

FIGURE 155. *Left,* The transection of the mandible at the symphysis with the Gigli saw. *Right,* The lateral retraction of the mandible and its laterally attached soft structures, the medial soft structures having been detached to be resected with the tongue, which has been hemisectioned. (A. J. Kremen: Surgery, Vol 30.)

FIGURE 156. The dissection of the lower neck, tongue, floor of mouth and submaxillary region has now been completed, and dissection posteriorly and superiorly will remove the primary tumor and the regional lymphatics of the area. Since the tongue has been hemisected, preservation of the hypoglossal nerve is unnecessary (*A J Kremen: Surgery, Vol. 30*)

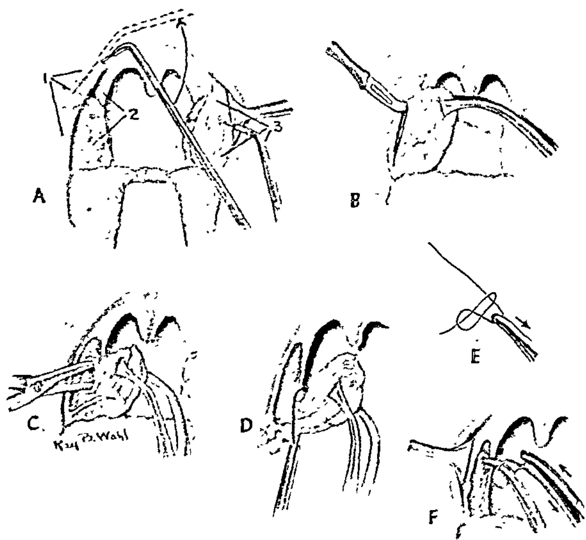


FIGURE 158. Technique of tonsillectomy under local anesthesia. (See text.)

fossa is now readily visible and may be cut with a scissors, as shown in Figure 158, *C*, or may be pushed away from the tonsil with a semisharp saw-tooth dissector such as the Fiser dissector. When the tonsil has been divested of all its attachments except inferiorly, it is encircled with a snare and removed, as seen in Figure 158, *D*, which also shows some lingual lymphoid tissue being removed. Lariat type ties of *dry* chromic 000 catgut are now made, as noted in Figure 158, *E*, and are carried down around a hemostat grasping a bleeding point, as seen in Figure 158, *F*. While the carrier hemostat is held steady, the free end of the suture is pulled taut, ligating the bleeding point. Tissues in the superior half of the tonsillar fossa are loose and lend themselves well to this type of ligature; however, in the inferior half of the fossa the tautness of the tissues is apt to cause this type of tie to slip, and here it is better to suture the bleeding point with a mattress type of suture, using catgut on an atraumatic needle. Ligatures are placed until no more bleeding is apparent.

Technique of Tonsillectomy and Adenoidectomy under General Anesthesia

If a tonsillectomy alone is to be done, nasotracheal intubation will give the operator more operative room and less annoyance from the tube; however, if adenoidectomy is to be done, the tube must be passed orally and displaced laterally opposite to the side being operated on. The mouth is opened with a self-retaining gag, and some operators prefer a gag which also holds the tongue blade. Some operators prefer

to then inject the tonsils with adrenalinized procaine, as described above. They state that it lessens bleeding, which is generally more troublesome under general anesthesia and, by virtue of its own anesthetic qualities, requires less general agent. The operation then proceeds as described above. The adenoidectomy is begun after completion of the tonsillectomy. There is no place for "blind" adenoidectomy. One of the various types of palate retractors is used to displace the soft palate forward and upward to permit visualization of the nasopharynx. The bulk of the adenoid may be removed with a guillotine type of instrument such as the LaForce adenotome.

The instrument is introduced into the nasopharynx in the midline, and, with the blade open, pressure on the posterior nasopharyngeal wall is made with the instrument to force the mass of adenoid into the fenestra of the instrument. The blade is now closed, cutting off the mass of adenoid. The blade is left closed to retain the adenoid in the basket of the instrument until it is removed from the patient. Any lateral masses of adenoid may be removed in a similar manner, taking care not to injure the torus tubaris on either side. Excessive lymphoid tissue remaining in Rosenmueller's fossae must now be removed under direct visualization, using special punches designed for this purpose, as the Goodyear or Meltzer instruments. If there have been symptoms of chronic eustachian tube obstruction before operation, removal of lymphoid tissue in this area must be carefully accomplished.

Bleeding from the adenoid-bearing area may be brisk momentarily, but will usually stop with gauze pressure. Any persistent bleeding points may be grasped and ligated as described for tonsillectomy, or controlled by a pressure gauze pack left in for a while. This may be fashioned from a four-by-four gauze rolled up and tied with a heavy silk suture. After insertion of the gauze into the nasopharynx, the suture is allowed to come out of the mouth and is taped to the cheek, to be used for retrieving the pack by traction.

Postoperative Care. Both the conscious and unconscious patient are transported from the operating suite to the hospital room lying prone to prevent aspiration of blood. With cessation of anesthesia, either local or general, there is considerable pharyngeal pain, especially in adults, and a constant desire to clear the throat. This may incite bleeding. A good practice in adults is to give an appropriate dose of morphine or Demerol immediately when the patient complains of pain. By the time the effect of this opiate has been lost, the patient will have only soreness of the throat. No food or water is given for the first six postoperative hours, after which the patient is encouraged to eat. An ice collar to the neck in the immediate postoperative period may give comfort. On the first postoperative day and following days, aspirin gum is prescribed as needed for pain, and warm normal saline gargles are used after meals. Healing of the throat is generally complete in fifteen days.

Complications. Bleeding is the chief complication. If it occurs within the first six hours after operation, it is due to a ligature coming off a vessel or failure of the operator to identify and ligate a potential bleeding point. The treatment is ligature either by suture or a free tie. Delayed bleeding occurring from the fourth to seventh postoperative days is believed to be due to liquefaction of clot in the cut ends of vessels from superficial infection. The fossae may fill with clot, with continual seepage of blood from around the edges, or less frequently, there may be active bleeding from an area with little clot formation. The removal of the clot with a ring or sponge forceps may be all that is necessary to stop the bleeding. If bleeding persists from one

point, it should be controlled with a mattress suture. Bleeding from multiple points is best controlled by covering a tonsil sponge with a piece of hemostatic oxycellulose gauze and thrusting this into the bleeding fossa, where it is held in place by suturing the anterior and posterior tonsillar pillars over it with heavy silk. This pack should be allowed to remain twenty-four hours. Some physicians recommend the routine use of antibiotics postoperatively to prevent fossa infection and delayed bleeding. Probably the use of saline gargles and insistence that the patient eat to keep eschar (slough) from forming in the fossae are more important and beneficial.

OPERATIONS UPON THE SALIVARY GLANDS

SUPPURATIVE PAROTITIS

Technique of Incision and Drainage

An incision is made at the junction of the cheek and the ear (Blair and Padgett). To expose the whole gland, the incision begins 2 cm. in front of the ear at the lower border of the zygoma, extends back to the ear and downward behind and below the angle of the jaw. This incision should be extended to cut through the capsule of the gland, but not deeper. A flap of skin and superficial fascia is dissected forward to expose the entire gland. The gland capsule is stripped off, and the gland is punctured in numerous places with a pointed hemostat. The facial nerve lies deeply beneath the incision and will not be injured by this procedure. The wound is packed open with petrolatum gauze, and a light pressure dressing is applied.

Early operation is indicated in the acute cases to prevent spread of infection and necrosis. Salivary fistula is avoided by not making direct incisions into the gland. The infection is serious.

SALIVARY CALCULUS

Technique of Excision

Salivary calculi are found in the ducts or within the glands. They are most frequently found in the submaxillary gland duct.

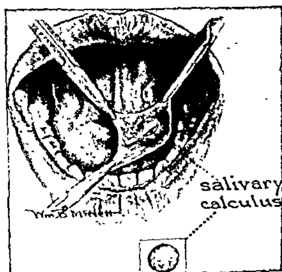


FIGURE 159 Method of exposure of salivary calculus in submaxillary duct. (Babcock: Textbook of Surgery)

An incision is made through the mucosa of the mouth over the stone. Extraction of the stone is usually not difficult (Fig. 159). If a stone is found in the substance of the parotid gland, an external incision may be necessary. Here the facial nerve must be avoided. A stone removed externally from the parotid gland may produce a salivary fistula if the duct is not kept patent by incision or dilatation within the mouth. Wounds in the mucous membrane and duct in the mouth do not require suture.

RANULA

Mucous retention cysts lying in the floor of the mouth are generally called ranulas because of a supposed resemblance to the ventral surface of the frog. These are usually associated with the sublingual glands and may be unilateral or bilateral. In most instances excision of the superficial presenting portion of the cyst wall under local anesthesia is sufficient to effect a cure. Complete removal of the cyst is difficult and in most cases unnecessary.

PAROTID TUMOR

General Considerations

The vast majority of parotid gland tumors are of the so-called benign mixed tumor variety. Although these tumors do not metastasize, the recurrence rate is high. In some instances recurrence may represent multicentricity of origin of the tumor; more often, however, it is the result of incomplete removal. These tumors are often small and appear to be superficial beneath the underlying skin, leading the unwary to initiate surgical excision under local anesthesia as an office or outpatient procedure. This plan will almost invariably lead to incomplete excision and recurrence of tumor, and secondary operation in the face of scarring is an unsatisfactory procedure. For this reason all tumors in this area should be regarded as lesions requiring a major surgical procedure under general anesthesia when complete excision of the tumor and surrounding gland can be done without injury to the underlying facial nerve.

Dangers and Safeguards

The most important structure to be preserved is the facial nerve (Fig. 160). The nerve does not always pass through the gland. With reasonable care the nerve can be dissected from the gland and preserved in a great majority of cases. It is possible to totally excise the parotid gland without injury to the facial nerve. The formation of a salivary fistula may result if one of the larger ducts of the parotid is cut across and not closed. This rarely happens in the ordinary dissection of a tumor.

A tumor may recur if a small portion of the tumor or its capsule is not excised, and when small seedling tumors, lying beyond the capsule of the primary tumor, are overlooked.

Total excision of parotid tumors is the treatment of choice. When the tumor is definitely malignant, the entire gland should be removed even if sacrifice of the facial nerve is necessary. Radiotherapy is generally unsatisfactory. In general, parotid tumors are very radioresistant.

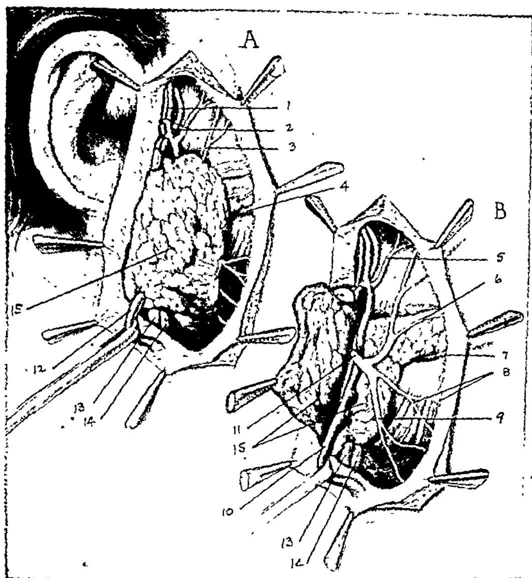


FIGURE 160. Superficial and deep dissections of the parotid region. *A*, The parotid gland is exposed to show its normal relation to vessels and nerves *B*, The outer part of the parotid gland is retracted to show the vessels and nerve which traverse it *1*, N auriculo-temporalis; *2*, A and V temporalis superficialis; *3*, ramus temporalis N. fac [illegible]
ticus N. facialis; *7*, ductus parotid [illegible]
facialis; *10*, V. jugularis externa, [illegible]
facialis posterior; *15*, glandula parotis (Callander. Surgical Anatomy)

Technique of Excision of Parotid Tumor (Janes) (Fig. 161)

Intratracheal anesthesia is usually desirable. Draping should be done to include the entire face to the midline in the operative field This permits definite identification of the branches of the facial nerve by observing twitching of the facial muscles when applying light pressure or electrical stimulation to the nerve fibers.

The incision is started over the mastoid process and extended downward below the ear along the sternocleidomastoid muscle a distance of about 8 cm. This incision may be sufficient for the removal of small tumors, but for large or malignant tumors a second incision is made in front of the ear to join the first incision below the ear to form a Y with an obtuse angle. Through the upper portion of the first incision the great auricular nerve is identified and retracted. The anterior border of the sternocleidomastoid muscle is exposed, and part of its anterior attachment to the mastoid

process is cut to increase exposure. By retracting the sternocleidomastoid muscle the posterior belly of the digastric muscle is exposed.

A flap of skin is raised and retracted forward from the surface of the tumor. The tumor is partially mobilized, and the tip of the styloid process and the transverse process of the axis are identified. By dissecting upward along the anterior border of the digastric muscle the facial nerve is exposed at or just anterior to the stylomastoid foramen. To improve exposure, a portion of the mastoid process may be removed with an osteotome. Traction on the nerve must be avoided, since it is fixed at its origin.

After the nerve has been identified, dissection is carried forward, and the various nerve branches are identified and protected. If the tumor is large or malignant, ligation of the external carotid artery is advised to prevent excessive bleeding. Before exposing the artery the inframandibular nerve should be identified to protect it from

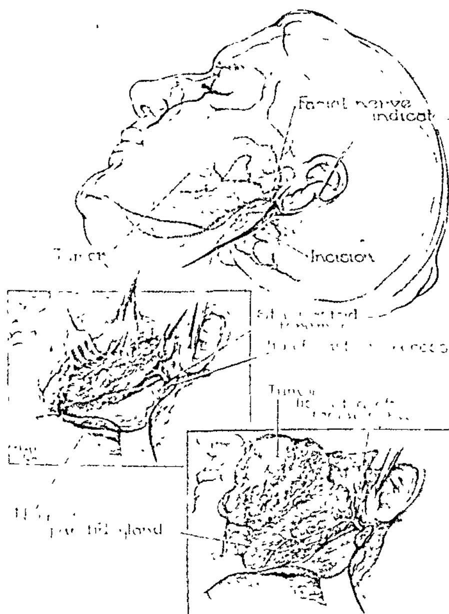


FIGURE 161 Technique of removal of parotid tumor. Type of incision used to expose the facial nerve and remove a parotid tumor The nerve is exposed first, and its branches are identified as the dissection proceeds When such an exposure is made, a portion of gland with the tumor may be removed without danger of permanent injury to the nerve (Janes S Clin North America, Vol 23, W B. Saunders Company.)

injury. If the tumor appears to be benign, the nerve fibers are dissected anteriorly far enough to permit its removal with a portion of surrounding normal gland tissue. If the growth appears to be malignant, nerve fibers entering it should be sacrificed. Definitely malignant tumors should usually be treated by total parotidectomy. Tumors lying beneath the nerve can usually be delivered between the nerve branches without producing more than temporary paralysis.

After removal of the tumor the wound in the gland and surrounding tissues is closed with sutures. The skin is closed with interrupted sutures of silk or cotton placed close to the wound margins to prevent excessive scarring. A small rubber tissue drain is inserted in most instances.

Technique of Excision of the Parotid Gland (Padgett)

Excision of the parotid gland is rarely indicated except for malignant tumors. It is difficult and often impossible to preserve the facial nerve, since it is usually involved in the tumor mass. In order to remove the entire tumor, resection of the mandibular ramus may be necessary. In cases of carcinoma of the parotid a neck dissection may also be indicated.

The incision begins at the lower border of the midportion of the zygoma, extends backward to the ear and downward in front of the ear to a point below the angle of the jaw. Redundant skin or skin attached to the tumor is removed by making an elliptical incision.

The dissection is begun at the lower margin of the tumor, and all vessels are ligated as the operation progresses. The plane of dissection is outside the parotid capsule. Below the lower portion of the tumor the digastric and stylohyoid muscles are identified. The parotid sheath, which is continuous with the sheath of the sternocleidomastoid muscle, is separated from this muscle, and the external carotid artery is exposed. This vessel is ligated. The hypoglossal nerve, which passes over the artery, is preserved. The temporal artery and vein are exposed about where they cross the zygoma and ligated. Dissection is continued to isolate the entire mass down to the ramus of the mandible. If the tumor is attached to the jaw, a Gigli saw is passed behind the ramus, and the posterior portion with the condyle is cut off. The condyle is twisted from its socket, and the entire mass of parotid tumor and bone is removed.

The wound is closed with drainage.

EXCISION OF SUBMAXILLARY GLAND

General Considerations

Excision of the submaxillary gland is much simpler than excision of the parotid gland, since one does not have to contend with the facial nerve. The submaxillary gland may be the site of mixed tumor, this gland being involved in approximately 10 per cent of mixed tumors. It may also be involved in recurrent infection secondary to salivary duct calculus with subsequent scarring and duct stenosis. Although removal of the calculus may result in cure, many of these cases will continue to have recurrent infection because of resultant stricture of the duct requiring removal of the gland.

Excision of the submaxillary gland is most often done as an incidental part of radical neck dissection.

Technique of Operation (Fig. 162)

General anesthesia is preferable. A 5-cm. incision is made approximately 1 cm. below the mandible, overlying the submaxillary gland. The incision is carried down through the subcutaneous tissue and platysma muscle to the cervical fascia. Retraction of the superior portion of the wound is made with care to avoid injury to the mandibular portion of the facial nerve. The cervical fascia is then incised over the gland in the same plane as the skin incision. The anterior facial vein, which crosses the gland, is then divided and ligated. The external maxillary artery parallels the course of the anterior facial vein, although in most instances it crosses posterior to the gland and need not be ligated. The gland is then grasped with a forceps and dissected from surrounding tissue under direct vision. The submaxillary duct is identified anteriorly, ligated and divided. As the gland is retracted downward, care must be taken not to injure the lingual nerve, which gives off branches to the gland and may be pulled downward when the gland is retracted. Inferiorly, the hypoglossal nerve must similarly be protected from injury. When the gland has been removed, the wound is checked for hemostasis and irrigated with saline solution. Closure is carried out with interrupted silk sutures. In most instances drainage of the mylohyoid fossa with a small Penrose drain is indicated.

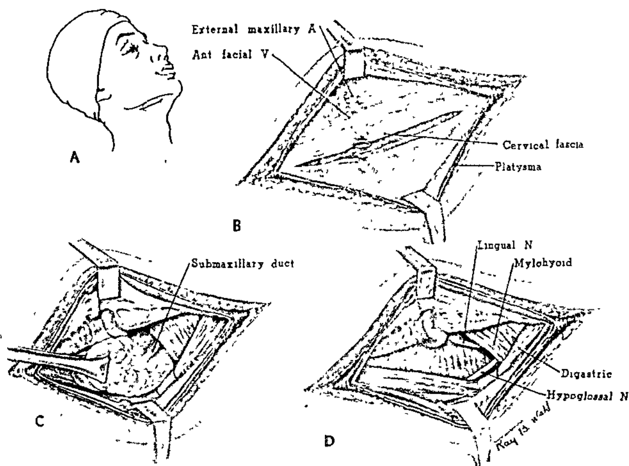


FIGURE 162 Excision of the submaxillary gland *A*, Incision *B*, Incision of the cervical fascia and ligation of the anterior facial vein *C*, Dissection of the gland from surrounding tissue. *D*, Mylohyoid fossa after removal of the gland Care must be taken to avoid injury to the lingual and hypoglossal nerves.

OPERATIONS UPON THE NECK

CYSTIC HYGROMA

General Considerations

A cystic hygroma is present at birth or appears at an early age. It usually occurs in the neck or axilla and is called hygroma colli cysticum and hygroma axillare. Rare cases have been described in which the growth occurred in the groin and retroperitoneal space. A true hygroma is a benign, multilocular cystic tumor arising from lymphatic tissue. The cysts are lined with endothelium.

Hygromas have great power of penetration and even destruction of tissue, extending at times deep into the tissues of the neck, axilla or even the mediastinum.

Dangers and Safeguards

With expectant treatment, infection may ensue with serious or fatal results. Complete excision is the treatment of choice, although it is somewhat dangerous at a very early age. Aspiration, injection of sclerosing solution, incision and drainage, and the use of radium or x-ray are all treatments of doubtful value. *Prolonged operation with hemorrhage and shock* is the chief immediate danger. Since the growth may involve important structures such as the trachea, large vessels and nerve trunks and plexuses, technical difficulties may be encountered. The danger of *nerve injury* with resulting permanent paralysis is great. Goetsch stresses the importance of preserving the tumor intact, when possible, throughout the operation to facilitate the dissection. Collapsed thin-walled cysts have poorly defined margins making dissection difficult, particularly if there is much fibrosis. Recurrence is almost certain if any portion of the tumor is not removed.

Technique of Operation

A general anesthetic is indicated. The type of skin incision varies much, but is usually made elliptical to remove redundant skin with the growth. Dissection is carefully made, and all bleeding is controlled as the operation proceeds All anatomical structures must be identified and important structures protected from injury. If the growth surrounds nerves or important vessels, it should be dissected off with great care. Where fibrosis has developed, sharp dissection is necessary. Preservation of the growth intact makes dissection much easier.

The skin wound is carefully closed with fine silk, usually without drainage. A pressure dressing aids in the approximation of skin to underlying tissues.

THYROGLOSSAL CYST AND SINUS

General Considerations

Thyroglossal cysts and sinuses are the congenital remains of the fetal thyroglossal tract. The cysts are found in the midline of the neck, usually near the hyoid bone, although the cyst proper may lie to either side of the midline They are most commonly seen in childhood, but may appear later in life. The diagnosis is not difficult if one is familiar with this type of congenital anomaly.

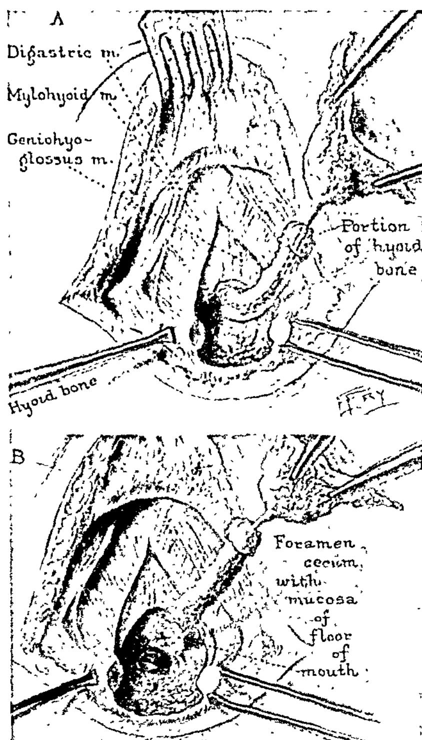


FIGURE 163. Excision of thyroglossal tract. *A*, Through a transverse incision a short segment of the hyoid bone has been removed. The thyroglossal cyst and tract have been dissected free to a point near the base of the tongue. *B*, The duct, with muscles surrounding it, has been "cored out" to base of tongue. The foramen cecum may be seen (Sistrunk: Ann Surg, Vol 71, J B Lippincott Company.)

Dangers and Safeguards

Thyroglossal cysts not infrequently become infected and are incised and drained. Such treatment may be indicated to control infection, but will not effect a cure. Complete excision of the cyst with the thyroglossal tract is the only curative treatment. Excision up to the hyoid bone is not sufficient The dissection should be continued to the foramen cecum. A discharging sinus may persist for years or may intermittently open and close. Cauterization and the injection of antiseptic or sclerosing solutions are useless types of therapy.

Technique of Operation (Sistrunk) (Fig. 163)

General anesthesia is advisable. The position on the table is the same as that used for thyroidectomy.

A transverse incision 5 cm. long is made just below the hyoid bone. The skin and platysma muscle are reflected to expose the cyst lying beneath the raphe connecting the sternohyoid muscles. Methylene blue may be injected to aid in the identification of the sinus tract. The cyst and sinus are dissected free up to the hyoid bone. The sinus tract may pass anterior, posterior or through the hyoid bone. A section of the hyoid bone 0.5 cm. wide is resected with the sinus. Above the hyoid bone the tissues are cored out up to and including the foramen cecum. A finger or tongue depressor lifting the base of the tongue forward will aid in the dissection. The sinus is followed along a line which corresponds to a line drawn 45 degrees from the intersection of horizontal and perpendicular lines drawn from the middle of the anterior-superior portion of the hyoid bone.

The opening at the base of the tongue is closed. The geniohyoglossus muscles are sutured. The ends of the hyoid bone are approximated by sutures placed in the surrounding fibrous tissue. A small rubber tissue drain is inserted, and the platysma and skin are closed with fine interrupted sutures.

BRANCHIAL CYST AND FISTULA

General Considerations

Congenital branchial cysts or fistulas occur in the side of the neck along the anterior border of the sternocleidomastoid muscle. They may occur at any level in the neck. The fistulous tract extends upward beneath the anterior border of the sternocleidomastoid muscle anterior to the carotid sheath. High in the neck, the tract lies beneath the posterior belly of the digastric muscle. At this point it arches medially behind the stylopharyngeus muscle to end in the tonsillar fossa.

Dangers and Safeguards

A knowledge of the anatomy of the neck is necessary for safe operating for a branchial cyst or fistula There is little danger of hemorrhage or shock in an adult unless a large neck vessel is wounded. Cysts and fistulas must be excised completely to prevent recurrence

Technique of Operation

A branchial cyst lies beneath the upper end of the sternocleidomastoid muscle. An incision is made along the anterior border of this muscle, which is retracted backward, and the omohyoid muscle forward. The carotid artery and jugular vein are identified and protected by retraction. Injury to the vagus and hypoglossal nerves is avoided A branchial cyst usually can be removed without difficulty if dissection is made close to the cyst wall.

A branchial fistula may be injected with methylene blue to aid in the visualization of its tract. An elliptical incision is made about the fistulous opening, and from

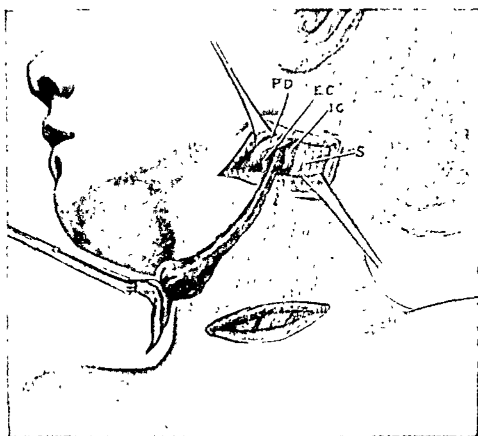


FIGURE 164. Operative incisions for the removal of a branchial cyst or fistula Lower incision shows an elliptical piece of skin removed about the opening of the sinus. (Ladd and Gross: Am J. Surg., Vol 39.)

this the skin incision is extended upward along the anterior border of the sternocleidomastoid muscle. To avoid excessive scarring, Ladd and Gross make one or two transverse incisions depending upon the length of the fistulous tract (Fig. 164). The dissection of the tract is begun where it opens through the skin and proceeds upward to its ending in the tonsillar fossa.

The fistulous tract should be removed completely to its opening into the pharynx. After the dissection has been completed the stump may be attached to a probe with a stitch and invaginated into the pharynx. To aid in the final steps of the dissection, an assistant may push the pharynx wall outward with an index finger against the tonsillar fossa. With this maneuver Ladd and Gross state that the tract can be ligated within 2 to 3 mm. of the tonsillar fossa, and invagination of the stump into the pharynx is not required.

The wound is closed with fine catgut and silk. A small rubber tissue drain is advisable.

CERVICAL LYMPH NODES

General Considerations

Neck dissection for removal of diseased lymph nodes may be indicated in Hodgkin's disease, tuberculous adenitis, primary endothelioma, metastatic carcinoma, carcinoma arising from a branchial cleft, and rarely for lymphosarcoma and tumors of the carotid body. The dissection depends upon the extent and character of the

disease. Local removal may be indicated when the nodes are locally involved. When removing nodes for metastatic or suspected metastatic involvement, block dissection, to include both lymphatic vessels and nodes, is always advisable. According to Bartlett and Callander, the neck may be divided into two regions—the suprahyoid and lateral—from the metastatic standpoint. Primary carcinoma of the lower lip and skin of the face below the mouth metastasizes to the glands in the suprahyoid region, and carcinoma of the cheek, tongue, tonsil, pharynx, antrum and lateral portions of the face metastasizes primarily to the lateral regions of the neck. If the primary lymph nodes are grossly involved with metastatic carcinoma, it is the general rule to remove both primary and secondary nodes.

Before attempting extensive dissections of the neck, it is recommended that works on the anatomy of this area be carefully studied.

Dangers and Safeguards

To avoid damage to important structures, they must be identified as the dissection proceeds. The spinal accessory, vagus, phrenic, recurrent laryngeal, facial, lingual, hypoglossal, marginal branch of mandibular, and brachial plexus nerves are to be located and preserved. On the left the thoracic duct must be avoided. Removal or ligation of the carotid artery may result in hemiplegia in patients of advanced years. One jugular vein may be removed without danger.

A liberal incision, careful hemostasis and identification of important landmarks will minimize the danger of damage to important structures.

Technique of Suprahyoid Neck Dissection (Bartlett and Callander) (Fig. 168)

This operation seldom is indicated, the complete neck dissection being preferred whenever possible.

A cut-throat type of incision is made, which extends from one mastoid process to the other, passing just above the hyoid bone. If the dissection is to be unilateral, it extends from the mastoid to a point just beyond the midline.

The superior flap, including skin and platysma muscle, is dissected up to the margin of the mandible. The lower flap is reflected a short distance to expose the hyoid region and upper anterior margins of the sternocleidomastoid muscles. With a sharp knife the fascia is incised along the mandibular border from the sternocleidomastoid muscle to the chin. With blunt dissection all tissue is freed downward from the parotid gland, periosteum of the mandible and outer surface of the mylohyoid and hyoglossus muscles. The facial vessels should be cut and ligated where they pass over the ramus of the jaw. At this point the marginal branch of the mandibular nerve (seventh) must be isolated and retracted out of danger. If this nerve is severed, permanent paralysis of the muscles at the angle of the mouth will result. As the mylohyoid and hyoglossus muscles are cleaned off, the submaxillary branch of the lingual nerve, submaxillary gland and duct, and a plexus of veins about the duct are encountered. The submaxillary branch of the lingual nerve enters the superior pole of the submaxillary gland and is exposed by retracting the gland downward. By severing the nerve branch to the salivary gland, the lingual nerve will retract out of danger. By traction downward on the submaxillary gland, its duct is exposed where it enters the floor of the mouth. The duct and accompanying veins are ligated and cut. At this

point the hypoglossus nerve must be identified near the salivary duct. It is often found in a mass of veins. This nerve is held aside as the dissection is continued downward to the posterior belly of the digastric muscle. The facial vessels are again ligated deep in the neck.

All tissues from the submaxillary and submental regions are removed together. They include the submaxillary salivary gland, the section of facial vessels crossing the space, all lymph nodes and areolar tissue. The mylohyoid floor is thoroughly cleaned. The parotid gland is not disturbed.

The platysma muscle is closed with fine catgut or silk and the skin with silk. A small rubber tissue drain, to be removed in twenty-four hours, will aid in preventing the accumulation of serum beneath the skin flaps. A light pressure dressing is used.

Technique of Neck Dissection (Bartlett and Callander) (Figs. 165 to 170)

Lateral neck dissection is usually combined with suprahyoid dissection as the so-called radical neck dissection. Its most common indications are metastatic carci-

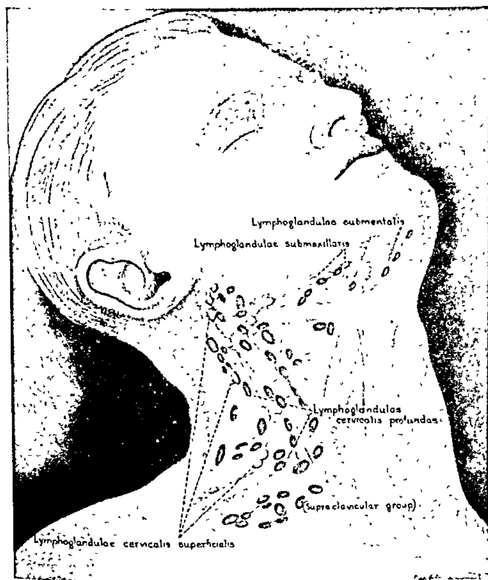


FIGURE 165. Schematic drawing to show the distribution of the lymphatic gland chains in the neck with their relationship to one another and to the neighboring structures (Bartlett and Callander. S. Clin. North America, Vol. 6.)

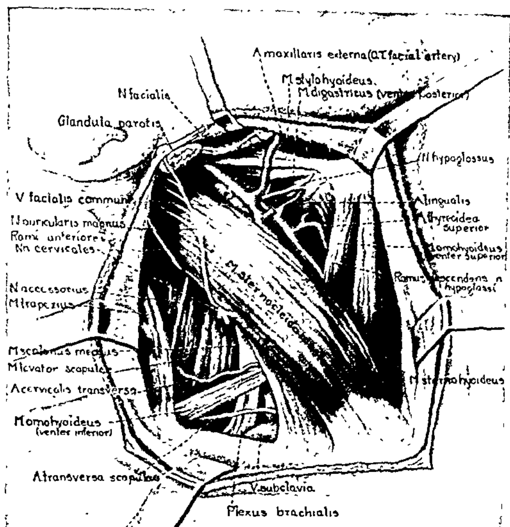


FIGURE 166. Dissection of the lateral region of the neck, showing anatomical structures and relationships (Bartlett and Callander: S. Clin. North America, Vol. 6.)

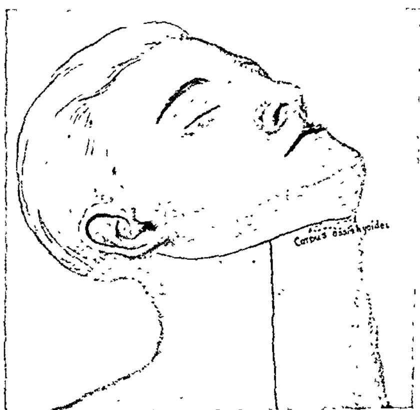


FIGURE 167 Incisions for neck dissections. The horizontal incision is used for suprahyoid unilateral dissection The vertical line is suitable for lateral dissection. (Bartlett and Callander: S. Clin. North America, Vol. 6)

noma from the buccal cavity and larynx. The neck dissection may precede, follow or be combined with removal of the primary lesion. If it precedes treatment of the local lesion, it serves to block off the area to be treated.

A T-shaped incision is used for the combined suprahyoid and lateral neck dissections. The vertical portion of the incision extends downward from the midportion of the suprahyoid incision to the clavicle near the attachment of the sternocleidomastoid muscle.

The submaxillary and two lateral flaps, with the platysma muscle, are dissected up, and the margin of the lower jaw is exposed above, the thyrohyoid muscle in front and the anterior margin of the trapezius muscle behind. The fascia at the margin of the trapezius muscle is incised, and the areolar tissue is separated down to the prevertebral fascia covering the floor of the neck. The spinal accessory nerve is exposed in this dissection and protected unless involved in tumor tissue. Medially, the dissection is carried down to the pretracheal fascia just lateral to the thyrohyoid muscle. This exposes the common carotid artery. The inferior limits of the dissection are next outlined by severing the sternocleidomastoid muscle immediately above the clavicle. The supraclavicular tissue is divided parallel to and 3 cm. above the clavicle. This line of dissection is about 2 cm. below the omohyoid muscle where it crosses the deep vessels. The lowest nodes of the deep cervical chain are below the omohyoid near the

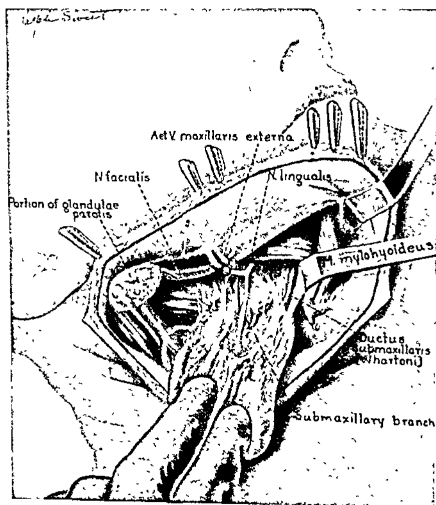


FIGURE 168. Suprahyoid dissection showing important anatomical structures. (Bartlett and Callander: S. Clin. North America, Vol. 6)

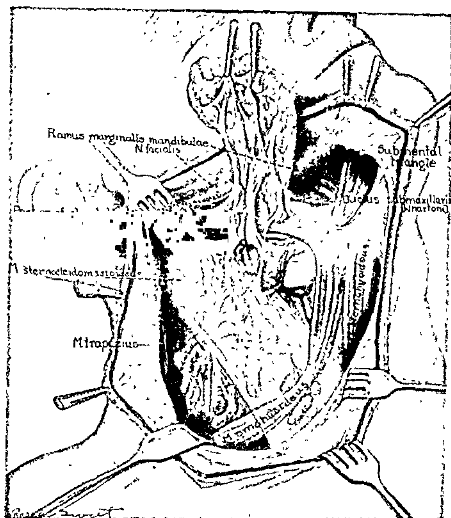


FIGURE 169. Early stage of a complete neck dissection. The superficial gland-bearing fascia has been dissected from underlying structures. (Bartlett and Callander: S. Clin. North America, Vol. 6.)

internal jugular vein. These nodes should be removed. The nodes above the subclavian vein need not be removed unless the lowest deep cervical nodes are involved. The external jugular vein is doubly ligated and divided. Almost directly beneath, the internal jugular vein is doubly ligated and cut. The dissection is continued inward to the prevertebral fascia over the deep muscles. Many small vessels and minor nerves will be divided, but none of great importance.

The removal dissection starts below and follows the prevertebral fascia upward. All areolar gland-bearing tissue and the jugular vein are included in the block to be removed. The common carotid artery, vagus nerve and thyroid gland are identified and preserved. The phrenic nerve and brachial plexus lie behind the prevertebral fascia. The prevertebral fascia covers the deep muscles of the neck. The small nerve branches from the brachial plexus are divided as they emerge from the deep fascia. All loose areolar tissue is removed from the common carotid, vagus nerve and prevertebral fascia. The bifurcation of the carotid is on a level with the larynx. The external carotid and its superior thyroid branch are identified, doubly ligated, and severed. At this point the internal carotid lies behind the external carotid. Further dissection upward exposes the stylohyoid and digastric muscles at their insertion on the hyoid bone. The hypoglossal nerve is identified as it loops below the posterior belly of the digastric muscle.

The next steps are usually the most difficult part of the dissection. The sternocleidomastoid muscle is cut away from the mastoid process, the lower pole of the parotid gland is resected, and the internal jugular vein is ligated near the skull. When the lower 1 to 2 cm. of the parotid is cut away, many small vessels will be encountered. Isolation and ligation of the jugular vein must be done with care to prevent injury to the vagus, hypoglossal and spinal accessory nerves, which lie close to the floor of the neck in this region. Mass ligation endangers these nerves. The jugular vein should be carefully isolated and ligated high so that the lymphatics intimately related to the vessels near the base of the skull may be removed.

It may be necessary to sacrifice the spinal accessory nerve. In exceptional cases, with extensive metastatic involvement deep in the neck, the hypoglossal nerve, vagus nerve, digastric muscle and stylohyoid muscle must be sacrificed.

The combined operation as described is indicated for metastatic carcinoma, carcinoma of the branchial cleft, and endothelioma of the neck. A lesser operation for removal of tuberculous or Hodgkin's glands may be indicated, with perservation of the sternocleidomastoid muscle, jugular vein and all important nerves.

The wound is closed with silk. A small drain is placed, to be removed in twenty-four to forty-eight hours. A light pressure dressing of gauze or marine sponge approximates the skin and platysma to tissues beneath and prevents the accumulation of serum under the skin flaps.

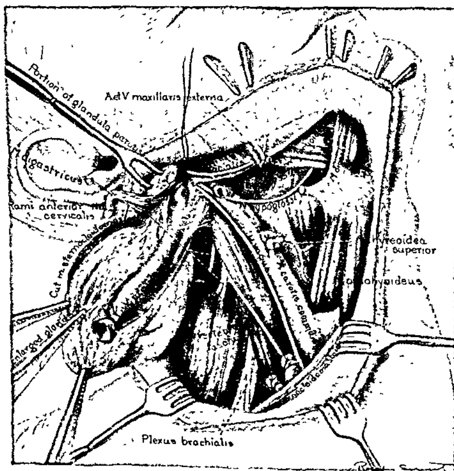


FIGURE 170. Late stage of complete neck dissection. The deep glands have been dissected free. The jugular vein has been ligated and is ready for removal with the mass of glands. (Bartlett and Callander: S. Clin. North America, Vol. 6)

OPERATIONS UPON THE LARYNX

General Considerations

Partial or complete excision of the larynx is frequently indicated for malignant growths. When the neoplasm is limited to a portion of one vocal cord, a thyrotomy or laryngofissure with excision of the affected cord may be sufficient. Somewhat more extensive neoplasms which have spread a short distance beyond the anatomic confines of the true cord may be adequately treated by hemilaryngectomy. Bilateral involvement of the vocal cords, the epiglottis or the aryepiglottic folds or the subglottic region of the larynx requires total laryngectomy for adequate primary removal, and *generally a concomitant radical neck dissection, for control of the lymphatic spread.* The scope of the operation will depend on the anatomic location of the tumor and to some extent on the histologic appearance. In general, the operation must be of such extent as to assure adequate removal of the primary growth and its metastases with some thought given to preservation of the more important functions of the larynx, that is, sphincteric, respiratory and phonatory. Laryngofissure or hemilaryngectomy preserves the respiratory and sphincteric functions quite well and the phonatory function to a satisfactory degree. Total laryngectomy, of course, removes all these functions. It is therefore necessary that the operator have detailed information as to the extent of the tumor, this being obtained by direct laryngoscopy, and some information as to the histology of the growth, this being obtained by biopsy.

With minor variations and some changes in terminology, the Walsh classification of laryngeal carcinoma is generally in use today. The classification is based upon the anatomic position of the tumor as follows: (1) *Intrinsic:* in this group the neoplasm is confined to one vocal cord and does not cross the anterior commissure. Neither is it so infiltrative as to limit significantly the motility of the cord. (2) *Endolaryngeal:* this probably actually represents extension of the intrinsic group so that the growth may be more extensive on the vocal cord, causing impediment of its motion, or may have crossed the anterior commissure and involved the opposite cord, or may have extended to some degree on the subglottic aspect of the true cord. (3) *Subglottic:* this includes all neoplasms below the vocal cord, generally indicating a growth that has begun primarily in this area. Most frequently subglottic carcinomas rise from the anterior laryngeal wall in the subglottic space. (4) *Extrinsic:* this group includes all neoplasms arising above the ventricular bands and would include those of the aryepiglottic folds, epiglottis and piriform sinuses.

When the neoplasm is extensive in the larynx, it is sometimes difficult to ascertain its point of origin. However, the history may be of value in providing this information. In general, hoarseness is the initial symptom in intrinsic and endolaryngeal growths. Increasing respiratory difficulty is usually the initial symptom of subglottic growths. Later in the course of this tumor laryngeal stridor and hoarseness may appear.

The first symptom of an extrinsic growth that the patient may notice is the appearance of a mass in the neck from an enlarging lymph node filled with metastatic tumor deposit Other symptoms of extrinsic growth may be slight but persistent sore throat with referred otalgia on the same side and/or cough occasionally productive of a scant amount of bright blood. Tumors arising anywhere in this area will, if

allowed to become large enough, eventually produce respiratory stridor and hoarseness.

Malignancies involving the phonating margin of the true vocal cords occur in an area relatively free of lymphatic channels; therefore early lymphatic metastases are not apt to occur. Malignant lesions involving other parts of the larynx, especially the aryepiglottic folds, epiglottis and piriform sinuses, occur in richly lymphatic areas where early metastatic spread may be anticipated.

DIRECT LARYNGOSCOPY

Direct laryngoscopy is a diagnostic procedure which exposes for visualization the larynx and its contiguous structures so that the extent of any disease process in this area may be ascertained, and also provides direct access for the passage of biopsy forceps for removing tissue for histologic study.

Anesthesia for direct laryngoscopy may be either topical or general, or a combination of both, the latter probably being preferable since it provides an unconscious, well relaxed patient upon whom the examination can be conducted in an orderly manner with adequate visualization of all areas. Impending laryngeal obstruction due to the magnitude of neoplastic growth is a relative contraindication to general anesthesia, since relaxation of the patient may cause the obstruction to become complete and require an emergency tracheostomy. Preoperative medication of barbiturates and opiates along with either atropine or scopolamine should be given in accordance with the patient's age and physical state so that moderately heavy sedation is obtained. The patient should then be placed in a sitting position and the soft palate, tonsillar regions and pharyngeal mucosa anesthetized by the topical application of 1 per cent tetracaine on moist, but not wet, cotton-tipped applicators. The patient is told to expectorate any excess of anesthetic solution, since most reactions to topical anesthetic agents are caused by the application of too concentrated a solution over too broad tissue surface in too short a time with resultant absorption of the agent in such quantities as to affect the central nervous system with production of convulsions, respiratory paralysis or cardiac paralysis.

It is wise to anesthetize only the palate area first and allow five minutes to elapse, then anesthetize the faucial regions with another five minute time lapse, and then the pharyngeal mucosa. The piriform sinuses are then anesthetized bilaterally with cotton wet with tetracaine solution held in the area with Jackson cross-action forceps for about five minutes. The patient is then asked to put out his tongue and to grasp it with a piece of gauze held in his thumb and forefinger. The larynx is then visualized with the indirect mirror, after which a 2-cc. syringe filled with 1 per cent tetracaine with a laryngeal cannula attached is introduced into the mouth, and under mirror guidance the tip of the cannula is introduced into the larynx. The patient is then asked to take a deep breath and say "HEEEEEE," and while he is doing this the Pontocaine solution is gently dropped on the vocal cords. The movement of the vocal cords will disperse the tetracaine over the entire superior area of the larynx. When the patient can no longer exhale and phonate, he is told to take in a breath which will suck the remainder of the tetracaine solution into the subglottic area. This procedure

is repeated three times at five minute intervals until the 2 cc. of tetracaine solution are used. During the time the anesthesia is being instilled into the larynx, the indirect method of laryngoscopy is used to visualize, as well as the procedure will permit, the extent of the laryngeal lesion. But of most importance by this method is the determination of motility of the vocal cords and of the arytenoids, for when one is dealing with neoplasm in this area, limited or absent motility of these parts usually denotes deep infiltration of the underlying muscle with tumor and will be a determining factor in increasing the extent of operation for its removal.

The patient is now placed on the operating table with the shoulders even with the edge of the head of the table and his head held by an assistant. The head must be held high with the vertex about 15 cm. above the level of the table. Extension must be slight. With gauze over the upper teeth for protection, the direct laryngoscope is introduced. The Jackson anterior commissure laryngoscope or its many modifications is the instrument of choice in direct laryngoscopy. The laryngoscope is introduced over the tongue to the back of the pharynx. The handle is then lifted upward, exposing the base of the tongue and the tip of the epiglottis. The laryngoscope is introduced further along the base of the tongue and anterior to the epiglottis so that the valleculae are carefully examined. The piriform sinuses are examined on each side. The laryngoscope is then partially withdrawn and introduced beneath the epiglottis and carried downward, exposing the interior of the larynx.

If the procedure is to be accomplished under combined topical and general anesthesia, only slight alterations are made. Upon completion of the topical anesthesia the patient is placed on the table, where the anesthesiologist produces relaxation with one of the curare-like compounds and insensibility with thiopental sodium. With the patient relaxed and asleep, the head is supported by the assistant and the procedure carried out as noted above.

Removal of tissue for histologic study is accomplished by any one of several types of laryngeal forceps. The tissue is best taken at the periphery of the lesion in order to minimize the chance of securing necrotic tissue unsuitable for histologic study. Of importance during the examination is the notation of motility of the various parts of the larynx, particularly the vocal cord and the arytenoids. When the procedure is accomplished under topical anesthesia, this may be done indirectly at the time of instillation of the anesthetic agent and directly by having the patient phonate "HEEEEEE" with the direct laryngoscope in place. When the procedure is accomplished under general anesthesia, motility of the larynx will largely have to be determined by the indirect method at the time of the instillation of the topical anesthetic; however, respiratory movements of the vocal cords may be watched during the direct examination, and considerable information concerning infiltration and fixation of the larynx may be had by palpating the part with the suction tip. In addition to determining motility, the examiner must carefully note the maximum visible anatomic extent of the tumor.

Upon completion of the examination all salivary secretions and any bleeding that may have been produced from biopsy are carefully aspirated and the laryngoscope withdrawn. If the neoplastic mass is large and obstructive, the patient must be watched carefully for laryngeal obstruction, particularly if the procedure is accomplished under general anesthesia.

LARYNGOFISSURE OR THYROTOMY

Dangers and Safeguards

The greatest danger from this procedure is bleeding from the site of vocal cord excision into the larynx and hence into the respiratory tract. Needless to say, hemostasis must be carefully accomplished in the area. If, at the end of the procedure, there is any doubt about the control of bleeding, it is wise to do a low tracheostomy for both respiratory and aspiration purposes. Subcutaneous emphysema also may be a complication of this procedure, since the respiratory tract is made to communicate with the subcutaneous spaces. This may be severe and extend from the zygomatic arches to Poupart's ligament. In order to minimize this complication, the patient is warned against forcibly clearing his throat postoperatively and especially against blowing his nose, which would force air through the cut thyroid alae into the subcutaneous spaces. A small rubber drain placed in the wound at a depth of the cut thyroid alae and extending out onto the skin also will minimize this risk, along with the use of moderately firm surgical dressings. A small amount of subcutaneous emphysema in the region of the incision is not an unusual occurrence and is generally of no consequence.

Technique of Operation

The patient is placed on the operating table in the sitting position, and, under the guidance of the indirect laryngeal mirror as described for topical anesthesia of the larynx for laryngoscopy, 10 per cent cocaine is dropped into the interior of the larynx, the patient exhaling and saying "HEEEEEE." This is repeated about three times at five minute intervals, instilling no more than a total amount of 1 cc. of 10 per cent cocaine. This method is preferred over instillation of cocaine into the larynx after it has been opened surgically, which provokes severe coughing, which not only causes apprehension on the part of the patient, but also disrupts the operative technique and disorganizes the operative field. The patient is then placed in the supine position with sand bags under the shoulders to promote hyperextension of the neck. The entire neck and face and anterior chest region are then carefully prepared and draped. Local anesthesia is then carried out by infiltration of the skin of the anterior neck with an attempt to block the superior laryngeal nerves bilaterally. These may be located as they pierce the thyrohyoid membrane by bisecting the distance between the thyroid notch and the superior thyroid cornu, and inserting the needle in this area until it is felt to perforate the rather dense thyrohyoid membrane, after which approximately 2 cc. of anesthetic solution are deposited.

Exposure will be somewhat better through a vertical midline incision extending from the hyoid bone downward to the cricoid cartilage. A better cosmetic result will be obtained if a transverse incision is made midway between the hyoid bone and cricoid cartilage. The incision is carried downward through the skin and platysma muscle and superficial fascia until the sternohyoid muscles are exposed. These are split vertically in the midline, exposing the thyroid cartilages.

If the vocal cord growth is at least 3 mm. away from the anterior commissure, the larynx may be opened exactly in the midline. The perichondrium is cut and reflected laterally from the incision for a distance of about 2 mm. The laryngeal cartilages, if not calcified, may be cut with a knife or a thyrotomy scissors. If they are

extensively calcified, a hand saw or, preferably, an electrically driven circular saw will be needed to cut the cartilages. The laryngeal mucosa is then cut through, and with lateral retraction the larynx can be opened as a book, exposing its interior and bringing immediately into view the vocal cords, laryngeal ventricles and ventricular bands. If the malignant growth is near the commissure, it is better to cut through the thyroid cartilage 3 mm. away from the midline *on the uninvolved side* so that the entire anterior commissure may be removed. With the cord exposed, using an instrument such as a Freer nasal elevator, the affected vocal cord is elevated subperichondrally, this elevation being continued posteriorly to the vocal process of the arytenoid. Cuts are then made above and below the vocal cord, and the entire mass, including the cord and tumor, is then excised posteriorly, along with the cartilagenous vocal process of the arytenoid. The raw area in the lateral larynx is carefully searched for bleeding points, which are controlled by electrocoagulation.

After the completion of excision of the cord the field is freed of blood and mucus by careful aspiration. The thyroid alae are brought together and held by several interrupted sutures of fine chromic catgut through the perichondrium, but not through the thyroid cartilages. A small slip of rubber drain is placed in the wound. The sternohyoid muscles do not require suture. Platysma and superficial fascia is approximated interruptedly, using fine chromic catgut; skin is closed with silk. A rubber drain is fixed to the skin with a silk suture. Sterile dressings under moderate pressure are applied.

Postoperatively, the patient is warned not to blow his nose or forcibly clear his throat. Codeine hypodermically is used both for the control of pain and for reduction of the cough reflex. Water by mouth is given at the end of six postoperative hours, and on the first postoperative day a full liquid diet is given. The rubber drain is removed in twenty-four hours; skin sutures are removed in four days.

HEMILARYNGECTOMY

This procedure is useful for the removal of tumors which have extended from the true vocal cord into the laryngeal ventricle or onto the ventricular band or slightly into the subglottic space immediately adjacent to the vocal cord. It provides a wider field of excision and yet maintains the sphincteric, respiratory and phonatory function of the larynx.

Technique of Operation

The procedure may be combined with a block dissection of the neck. The position of the patient is the same as for laryngofissure. Local anesthesia generally may be used. On the side of the lesion a skin incision is made at the level of the hyoid bone, extending from the anterior border of the sternocleidomastoid muscle to the midline, from which it is dropped vertically to the suprasternal notch. This flap, containing also the platysma muscle, is elevated The larynx is opened by sectioning the thyroid cartilages either in the midline or to the opposite side of the midline if the anterior commissure is involved. Growth is carefully inspected. The strap muscles are detached from the oblique line of the thyroid cartilage, and the entire area, including the thyroid ala, is widely excised. Hemostasis is carefully secured. A low tracheostomy is

then accomplished. A stent is then cut from such tissue-inert spongy material as Ivalon to fit the interior of the larynx. Over this is placed a split thickness skin graft taken from the thigh or abdomen, large enough to cover the raw area and provide an epithelial lining for the larynx.

The stent containing the graft, raw side out, is then placed in the larynx. It should fit snugly, but should not cause severe pressure. The incision is then closed in layers, without drainage. If there is any doubt about the stent's maintaining its position, stainless steel sutures passing from the skin into the larynx and stent and out the skin on the opposite side may be used. The skin graft will form a new epithelial lining for the larynx and will also promote healing and prevent extensive cicatrization, which might be productive of a severe laryngeal stenosis. The Ivalon stent is removed in approximately six weeks through the direct laryngoscope. If an adequate laryngeal airway is obtained, the tracheostomy tube may be removed at the end of ten weeks.

Postoperative care is the same as for laryngofissure except that immediately postoperatively swallowing may be difficult, and a nasogastric feeding tube may be necessary. Because of soft tissue exposure to the respiratory tract, broad-spectrum antibiotics should be administered.

TOTAL LARYNGECTOMY

General Considerations

Total laryngectomy is reserved for those laryngeal neoplasms too extensive to be removed by localized operations, as described above. It is the procedure of choice for lesions involving the aryepiglottic folds, the epiglottis and the piriform sinus areas. To a limited degree, extensions of epiglottic carcinoma to the base of the tongue may be effectively removed if excision of the posterior third of the tongue is done en bloc with excision of the larynx.

Dangers and Safeguards

The newer antibiotics have greatly reduced the incidence of postoperative soft tissue infections in the neck as well as of spreading infections into the mediastinum. Also, they have largely reduced the complication of aspiration pneumonia, which is generally due to aspiration of purulent material from infected soft tissues in the neck. Of importance preoperatively is adequate examination to determine the presence of purulent paranasal sinus disease which, if present, should be eradicated by proper means before laryngectomy is done. The same is true for severe oral sepsis. If severe peridontoclasia is present, all remaining teeth should be removed before laryngectomy. Preoperative antibiotic therapy covering a broad spectrum should be begun about four days before operation. The preoperative and postoperative use of antibiotics has largely been responsible for the discontinuance of the old two-stage method of laryngectomy of New and the one-stage method of Babcock, in which a high transverse incision was made to avoid drainage from the wound of the neck into the trachea and the removal of the larynx from above downward so that the opening into the pharynx might be closed early in the operation to prevent extensive contamination of the soft

tissues of the neck. The one-stage wide-field technique of Hoover is the one largely used, with minor variations to meet the pathologic state present.

Technique of Total Wide-Field Laryngectomy

The operation may be accomplished in part under local anesthesia, resorting to general anesthesia later in the procedure, or it may be accomplished under general anesthesia from the beginning. If general anesthesia is to be used, after the patient has been rendered unconscious and relaxed, an endotracheal tube is placed through the carcinomatous larynx into the trachea for the administration of oxygen and anesthetic gases. Some surgeons have raised the question of tumor implants into the trachea by passage of the endotracheal tube through the carcinomatous larynx; however, in general this is considered to be a minimal risk. If the operation is to be started under local anesthesia, this is first accomplished by infiltration of the soft tissues of the anterior neck with an injectable local agent. If desired, a bilateral cervical block may be accomplished; however, this is probably not advisable if obvious metastatic masses are present in the neck, for fear of dissemination of carcinoma cells from puncturing these structures in doing the cervical block. Other complications from bilateral cervical block are intradural injection of anesthetic agent producing a high spinal anesthesia; bilateral phrenic paralysis with resultant diaphragmatic paralysis; and inadvertent bilateral vagus attenuation, which might cause bilateral abductor paralysis of the larynx, allowing the vocal cords to adduct and causing severe laryngeal obstruction. Probably infiltration of the soft tissues of the anterior neck along the lines of the incision and infiltration of the deeper structures as they are encountered is all that is needed for local anesthesia, especially if reasonably heavy sedation consistent with the patient's age is given.

The patient is placed on his back with the neck in the hyperextended position. After the preparation and draping have been completed a U-shaped incision is made, which is carried downward to include the platysma muscle (Fig. 171). If only removal of the larynx is to be done, this incision may be made symmetrical with the vertical portions of the incision, almost paralleling the anterior borders of the sternocleidomastoid muscles, and the horizontal portion of the U-shaped incision being made about 2 cm. above the suprasternal notch. It is not necessary to extend the incision so far lateralward on the sternocleidomastoid muscles that the greater auricular nerves are sectioned. This produces objectionable numbness of the external ear and should be avoided.

If a neck dissection is to be done with the laryngectomy, then the vertical portion of the U-shaped incision on the side of the neck to be dissected should parallel the posterior border of the sternocleidomastoid muscle. The flap of skin thus outlined, along with the underlying platysma muscle, is elevated from below upward to about 2 cm. above the hyoid bone. This flap is then protected by wrapping in a warm, moist normal saline pack. If a neck dissection is to be done, the sternal and clavicular heads of the sternocleidomastoid muscle on the side to be dissected now may be detached from the sternum and clavicle. If local anesthesia is used, a small amount of anesthetic solution should be infiltrated into the area first, and this is true for subsequent section of the anterior ribbon muscles. The sternohyoid muscles are now identified and sectioned bilaterally just above their sternal attachments. This will expose

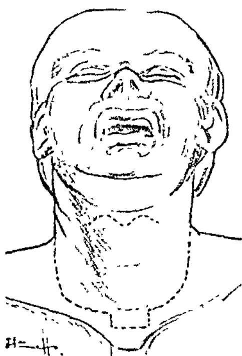


FIGURE 171. Outline of skin incision for wide-field laryngectomy. The tongue-shaped flap inferiorly may be omitted. (J. H. Ogura and J. A. Bello: Laryngoscope, Vol. 62.)

the sternothyroid musculature, which is similarly sectioned. The thyroid gland is now exposed. The isthmus is dissected bluntly from the underlying trachea and is clamped and ligated with a mattress suture of fine chromic catgut. The thyroid gland is now dissected free of the trachea and larynx. The omohyoid muscles are identified bilaterally and sectioned just as they emerge from under the anterior borders of the sternocleidomastoid muscles. The hyoid bone is then grasped in the midline with a tenaculum and pulled downward. If local anesthesia is being used, it is well to infiltrate the tissues in this area with more anesthetic solution. The suprahoid musculature is then detached from the superior aspect of the hyoid bone, including the geniohyoid, mylohyoid and hyoglossus musculature along with the tendinous portion of the digastric muscles between the anterior and posterior bellies and the stylohyoid ligament. With section of these structures the larynx will be made mobile.

The trachea is now sectioned between the cricoid cartilage and the first tracheal ring. A lower section may be required when one is dealing with a subglottic growth. If the operation has been conducted under local anesthesia to this point, a sterile endotracheal tube with an inflatable cuff is now placed in the stump of the trachea and with the aid of sterile flexible tubes is attached to the anesthetic machine. The cuff is inflated to prevent the ingress of blood into the trachea. It is wise to pack on top of the cuff between the trachea and the wall of the endotracheal tube, one-inch selvedge edge gauze. General anesthesia is now induced and the remainder of the procedure carried out under general anesthesia. If general anesthesia has been used from the outset, the endotracheal tube being used is removed, and a sterile tube is inserted into the lower trachea as noted above.

The proximal tracheal stump is now grasped with a tenaculum and dissected upward from the esophagus. In this area the tissues are very dense, being almost a raphe-like structure which generally requires careful sharp dissection staying close to the trachea in order to prevent perforation into the esophagus, which is rather thin-walled at this point. At the level of the vertical plate of the cricoid the attachment is much less dense, and further dissection may be accomplished with the gauze-covered

finger. When the esophagus has been dissected free of the trachea and posterior larynx, the larynx is then turned lateralward toward the side of the lesion. The inferior and middle constrictor muscles on the side opposite the lesion are then identified and dissected out bluntly, usually by passing the finger beneath the muscles, and detached from their insertion into the thyroid ala. This will allow the larynx to be further rotated to the side of the lesion and will expose the underlying pharyngeal mucosa. The superior thyroid cornu is then identified and a sharp incision made over it through the perichondrium, which is then elevated, exposing the cartilagenous superior cornu, which can then be resected with a scissors. In doing this, wide access is gained to the piriform sinus area. The pharyngeal mucosa is then doubly grasped with smooth-tipped forceps much as one prepares to open the peritoneum, and a small incision is made, opening into the pharyngeal cavity. This is further enlarged so that the operator's finger may be placed into the esophagus. The mucosa is cut through first inferiorly, staying as close to the larynx as possible, and then superiorly, sectioning between the base of the epiglottis and the base of the tongue (Fig. 172). As the larynx is turned further to the side of the lesion, the neoplastic growth becomes immediately visible, allowing the mucosa to be cut away with a margin preferably of at least 2 cm. from the visible edge of the lesion. When the pharyngeal mucosa is completely sectioned circumferentially from the larynx, the larynx remains attached only by the inferior and middle constrictor muscles on the side of the lesion (Fig. 173). These are sectioned, and the larynx is removed. A roughly triangular opening into the pharynx results. This is closed usually in a triangular manner, using a double-layer suture technique. A Connell stitch using 000 chromic intestinal catgut on a

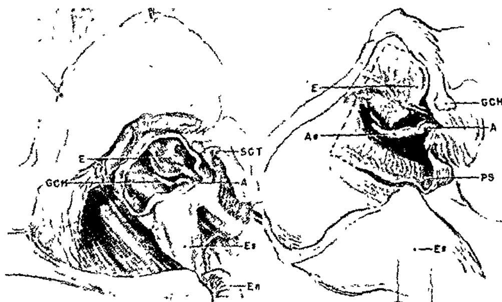


Fig. 172 Fig 173

FIGURE 172 The pharynx has been opened in the piriform sinus area opposite the side of the lesion. The larynx has been turned lateralward to the side of the lesion and is being sectioned between the epiglottis and the base of the tongue Abbreviations· *E*, epiglottis; *A*, arytenoid, *Es*, esophagus; *En*, endotracheal tube (J H Ogura and J A. Bello Laryngoscope, Vol. 62)

FIGURE 173 The larynx has been completely detached from the pharynx and is attached to the neck only by the constrictor musculature on the side of the lesion If no neck dissection is to be done, the constrictors are cut through and the larynx removed, otherwise they are allowed to remain attached to become part of the en bloc neck dissection (J H. Ogura and J A. Bello· Laryngoscope, Vol. 62.)

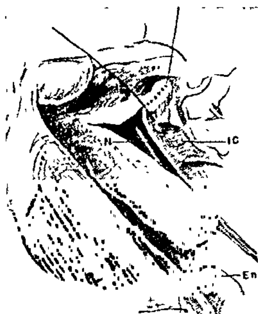


FIGURE 174. Closure of the pharynx after removal of the larynx. (J. H. Ogura and J. A Bello: Laryngoscope, Vol. 62.)

curved atraumatic needle is used for the first layer with a Lembert continuous suture of 000 chromic catgut for the second layer (Fig. 174).

This closure must be carefully accomplished in order to prevent postoperative pharyngocutaneous fistula. If the position of the neoplasm, especially those in the piriform sinus area, has required extensive resection of mucosa, closure may be somewhat difficult. This can be facilitated to some degree by decreasing the amount of extension of the head. It is surprising how much pharyngoesophageal mucosa can be resected and still preserve a functioning esophagus, even if only sufficient mucosa to suture in a single layer over a nasogastric feeding tube remains.

If only a laryngectomy is to be done, the constrictor musculature on the side of the lesion is now cut and the larynx removed. The cut ends of the constrictor muscles are now approximated in the midline over the esophagus, using interrupted sutures of fine chromic catgut. It is thought that reapproximation of the constrictor muscles forms a sort of sphincter for the upper esophagus and aids later in esophageal speech production. The wound is now vigorously irrigated with warm sterile saline solution and hemostasis carefully secured. An elliptical section is now cut out of the anterior tracheal wall so that the tracheal opening is actually made larger by virtue of the fact that it becomes a vertically placed ellipse rather than a circle. Small Penrose drains are placed in each lateral neck. The platysma and subcutaneous tissues are interruptedly approximated with fine chromic catgut. Skin incision is closed interruptedly with silk and the trachea sutured to the skin with silk. A nasogastric feeding tube is now passed by the anesthetist, the operator palpating the anterior neck as the tube passes through the cervical esophagus Passage of the tube is deferred until this time to prevent contamination of the wound by nasal secretions.

Sterile dressings in the form of gauze fluffs are now applied voluminously to the anterior neck, being held in place by elastic bandages applied in a circular manner around the neck. Care must be used that not too much pressure is applied which would result in bilateral jugular vein compression and severe edema of the head. A sterile no. 10 tracheostomy tube is placed in the trachea and fixed with strings tied in a hard knot.

Postoperative Care. As soon as the patient is awake, the head of his bed is elevated

to between 30 and 45 degrees. This minimizes regurgitation of gastric secretions into the esophagus and pharynx. Though the pressure dressings make it almost impossible for him to do so, the patient is told to expectorate all salivary secretions and not to attempt to swallow them. The mouth and trachea are aspirated as needed. Careful aspiration of the trachea during the first seventy-two postoperative hours is most important to prevent retention of secretions. Antibiotics administered preoperatively are continued postoperatively. A mild opiate is used for control of pain and an intramuscular barbiturate for sleep. Water is given through the nasogastric tube in small amounts on the operative day.

On the first postoperative day tube feedings are begun. These should be prepared so that the patient will receive approximately 2500 calories in approximately 2000 cc. of liquid each day. Intake and output records are kept. Feedings are generally given every three hours, and the amount 250 cc.; however, if this seems to be too much for comfort of the patient, or if there is a tendency to regurgitate, the amount of the feeding is reduced and the interval between feedings shortened.

In general, the first dressing need not be done until the third postoperative day, at which time the Penrose drains are removed. Pressure dressings are reapplied at that time. Skin sutures or clips are removed on the sixth postoperative day except the tracheocutaneous sutures, which are allowed to remain until the twelfth postoperative day. Pressure dressings are generally continued until the twelfth postoperative day and are then removed.

In general, most fistulas become apparent by the fifth postoperative day. These manifest themselves by a rather voluminous amount of mucinous material, usually at the site of one of the Penrose drains. If no fistula is present on the twelfth postoperative day, the patient is allowed to take water by mouth in unlimited quantities, the nasogastric tube being left in place for his tube feedings. If, after approximately two days, he is swallowing water without difficulty, the nasogastric tube is then removed and the patient put on a high caloric liquid diet for approximately three days and then on a soft diet. Antibiotics may be discontinued with the discontinuance of the pressure dressings. If there is fistula formation, this will be noted by excessive drainage of mucoid salivary secretions, as noted above, and by increased drainage when the patient attempts to swallow liquids by mouth. Most of these fistulas will close spontaneously if pressure dressings and tube feedings are continued, along with antibiotic coverage. Closure of the fistula is generally noted by absence of secretions on the surgical dressings. When this occurs, check may be made by having the patient swallow water, after which, if there is no leakage, treatment progresses as though no fistula had occurred.

LARYNGECTOMY COMBINED WITH RADICAL NECK DISSECTION

General Considerations

When metastatic masses are present in the neck, associated with a primary laryngeal carcinoma, removal of these masses en bloc at the time of total laryngectomy becomes mandatory [illegible]
neck dissection with la[illegible]

ever, from edema of the head and rising intracranial pressure from bilateral internal jugular ligation that it is probably better judgment to perform the laryngectomy and a radical neck dissection on the side having the larger metastases, then wait about six weeks for collateral circulation to be established, and dissect the opposite side of the neck. Some head edema may result from this type of procedure, but will not be as severe as when the simultaneous bilateral neck dissection is done.

Technique of Operation

Radical neck dissection is begun after the larynx has been severed from the pharyngeal mucosa, as described above, and after the opening in the pharynx has been sutured (Fig. 175). If the sternal and clavicular heads of the sternocleidomastoid muscle have not been detached previously as described above, this is now done. The internal jugular vein is exposed and doubly ligated with silk just above the clavicle. The inferior thyroid vessels are ligated and the thyroid gland detached from its adjacent structures. The supraclavicular fat pad is now dissected upward, carefully removing all lymph nodes in this area. Dissection of the strap and sternocleidomastoid muscles, internal jugular vein and supraclavicular fat is now carried upward to the level of the bifurcation of the carotid, removing also the fascial carotid sheath (Fig. 176). Care must be taken to identify and preserve the phrenic and vagus nerves in accomplishing the supraclavicular fat pad dissection. Care must be taken also not to injure the cords of the brachial plexus. On the left side the thoracic duct should be identified; much of the time this will be difficult, and the duct may be sectioned. Usually there will be a spill of chyle into the wound. Section of the thoracic duct



Fig 175

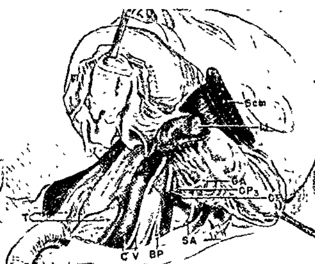


Fig 176.

FIGURE 175 The pharynx has been closed in preparation for starting the neck dissection. Pharyngeal closure is completed at this time, so that if the patient's condition should require termination of operation during the neck dissection, closure could be quickly accomplished Abbreviations: *SmG*, submaxillary gland; *GCH*, greater cornu of hyoid, *E*, epiglottis, *SCT*, superior cornu of thyroid; *PS*, piriform sinus, IC, inferior constrictor partially cut (J. H Ogura and J A Bello: Laryngoscope, Vol. 62)

FIGURE 176. Neck dissection has proceeded from below upward to the bifurcation of the carotid The internal jugul[illegible]
fat pad Abbreviat[illegible]
nerve; CP_1 and CP[illegible]
carotid; *T*, thyroid. (J H Ogura and J A. Bello: Laryngoscope, Vol. 62.)



Fig. 177.

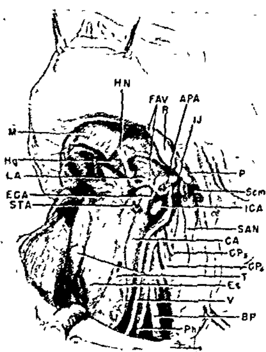


Fig. 178.

FIGURE 177. Dissection of the submandibular area. Abbreviations: *D*, cut ends of digastricus; *M*, mylohyoid muscle; *Smg*, submaxillary gland dissected posteriorly; *Hg*, hyoglossus muscle; *H*, hyoid bone. (J. H. Ogura and J. A. Bello: Laryngoscope, Vol. 62.)

FIGURE 178 Dissection completed. Larynx and contents of lateral neck have been removed Abbreviations: *M*, mylohyoid muscle; *HN*, hypoglossal nerve; *FAV*, facial artery and vein ligated; *R*, ramus of mandible; *APA*, ascending pharyngeal artery; *IJ*, internal jugular vein doubly ligated near base of skull; *Scm*, stenocleidomastoid muscle cut at mastoid process; *ICA*, internal carotid artery; *SAN*, spinal accessory nerve, *CA*, carotid artery, *CP3* and *CP4*, cervical plexus nerves III and IV; *T*, thyroid; *Es*, esophagus; *V*, vagus; *BP*, brachial plexus; *Ph*, phrenic nerve; *Hg*, hyoglossus muscle; *LA*, lingual artery; *ECA*, external carotid artery; *STA*, superior thyroid artery ligated. (J. H. Ogura and J. A. Bello. Laryngoscope, Vol 62.)

will cause no permanent damage if the rent is identified and closed either by suture if the opening is small or by complete ligation of the duct. Failure to do this will result in accumulation of chyle in the wound, which may cause considerable prolonged drainage. At the level of the bifurcation of the carotid, dissection is now stopped, to be begun anteriorly in the submaxillary region, progressing posteriorly and removing the submaxillary gland and submaxillary lymphatics (Fig. 177).

In this area care should be taken to prevent injury to the mandibular branch of the facial nerve and to the hypoglossal nerve. When the dissection of the submandibular mass has been extended posteriorly to the bifurcation of the carotid, dissection once again is continued in a posterior and superior direction until the internal jugular vein is dissected almost to the base of the skull, where it is again doubly ligated with silk and sectioned. The mass from the neck is now attached chiefly at the mastoid process, so that after section of the sternocleidomastoid muscle at this point the entire contents of the right neck and larynx can be removed (Fig. 178). If the metastatic masses in the jugulodigastric area are large, they will be in such proximity to the spinal accessory nerve that no attempt should be made to identify and preserve it. However, if the metastatic masses are small, the nerve may be dissected out and preserved. After removal of the contents of the neck the surgical procedure and closure progresses the same as after total laryngectomy alone. Postoperative care is similar also.

CARCINOMA OF THE LARYNX WITH INVOLVEMENT OF THE CERVICAL ESOPHAGUS

General Considerations

In the female most carcinomas in the general area of the laryngopharynx involve the posterior part of the larynx or the cricoid region and hence early involve the

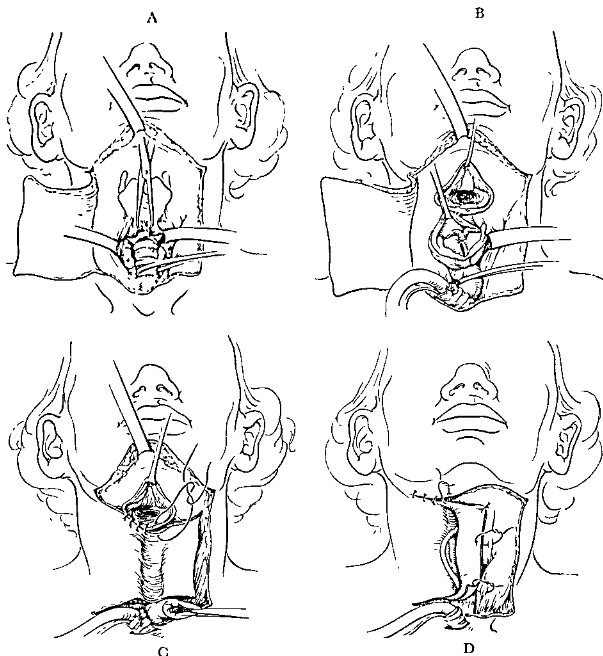


FIGURE 179 *A*, The laterally based skin flap The thyroid isthmus has been divided and the thyroid dissected free of the trachea The trachea is being severed from the larynx. *B*, An endotracheal tube has been placed in the trachea for administration of anesthetic gases. The pharynx has been completely sectioned above the hyoid, and the esophagus has been mobilized ready for division well below the lesion. *C*, Reconstruction of the pharyngoesophagus is begun by suturing the skin flap to the posterior pharyngeal and esophageal walls The flap lies directly on the prevertebral fascia. *D*, The flap is now sutured to the remaining pharyngeal and esophageal walls as shown, and the remainder of the flap is being used [illegible]
area is ac[illegible]
Any rema[illegible]
75.)

cervical esophagus. Adequate removal of these lesions, therefore, requires resection of the cervical esophagus along with the larynx and probably contents of one or both sides of the neck. In the male patient involvement of the cervical esophagus and cricoid region may result from a neglected laryngeal carcinoma which has spread into this area.

Technique of Operation

The procedure of Wookey is adaptable to reconstruction of the cervical esophagus after its resection in the female patient only, since skin of the anterior neck is used to form the esophagus and therefore must be free of hair. The initial incision of this procedure differs from that of the ordinary laryngectomy in that a rectangular incision is made, based on the side opposite to the one on which the neck dissection is to be done (Fig. 179, *A*). The procedure then progresses as described under total laryngectomy except that when the pharynx is opened laterally, the entire hypopharynx and cervical esophagus are resected as necessary to circumscribe the neoplastic lesion. Posteriorly, this exposes the prevertebral fascia (Fig. 179, *B*). Upon completion of the operation the skin flap is approximated to the pharynx and esophagus, as shown in Figure 179, *C*. The first stage is now completed by placing remaining sutures as shown in Figure 179, *D*. Any remaining raw areas are covered by Thiersch grafts. When healing is complete and nearly all reaction in the tissues has subsided, the second stage of the closure may be done as shown in Figure 180. After the esophagus has been closed in this manner the remaining raw area may be covered with a split graft, or, if sufficient mobility of the tissues can be obtained by undermining, direct suture of the defect may be accomplished. When healing is complete from this stage, the nasogastric feeding tube may be removed.

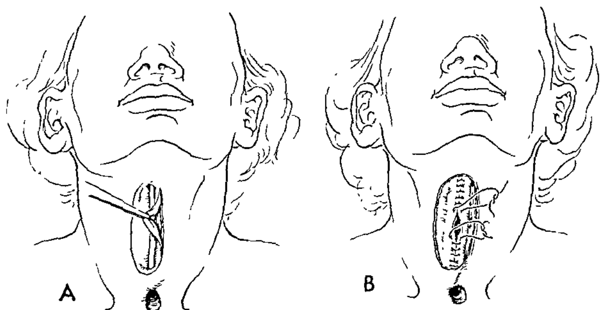


FIGURE 180 *A*, Method of completing the second stage of pharyngoesophageal reconstruction. This is carried out approximately 5 weeks after the first stage During this time nutrition of the patient has been maintained by high caloric feedings through a nasogastric tube. Closure of the lateral fistula is accomplished by incising and undercutting the skin and suturing as in *B* This should be a double-layer closure. Raw areas remaining are either closed by undermining the skin laterally and suturing, or, if there is insufficient tissue, a Thiersch graft is applied. Feedings by way of the nasogastric tube are continued for 2 weeks after this stage or until healing is complete. (H Wookey: Surg., Gynec. & Obst, Vol. 75)

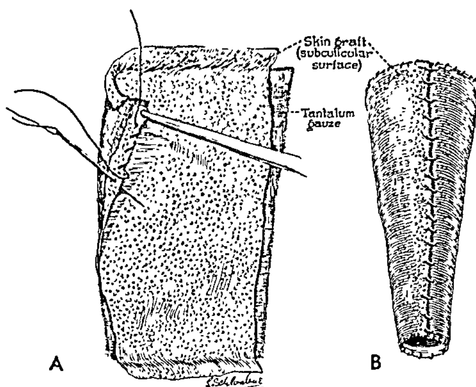


FIGURE 181. Method of applying split-thickness skin graft to tantalum mesh stent for one-stage reconstruction of cervical esophagus. (M. T. Edgerton: Surgery, Vol. 31.)

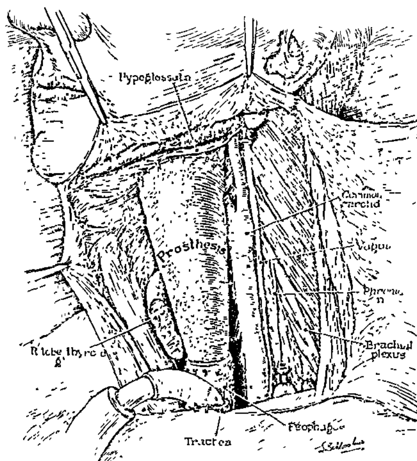


FIGURE 182. Skin graft on tantalum mesh prosthesis sutured in place to reconstruct the cervical esophagus (M T. Edgerton· Surgery, Vol 31)

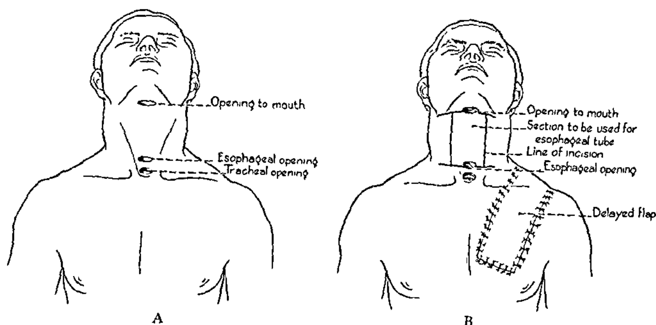


FIGURE 183. *A*, After laryngectomy with resection of the pharynx and cervical esophagus, pharyngeal, esophageal and tracheal stomas are constructed and allowed to heal. *B*, An acromioclavicular delayed flap has been prepared, taking an area 40 per cent larger than the apparent need to allow for contracture and migration of the flap, maintaining a width to length ratio of 3 to 8. The flap is delayed in 2 stages. The first elevation is made by an L-shaped incision, undermining, and replacing it for 7 to 10 days. The flap is again elevated, this time completing the second long incision and replacing it for 21 days. When the flap is ready for transplant, the neck incisions are reopened to the extent that the mucocutaneous margin of the pharyngeal stoma is opened in its anterior half, separating skin and mucosa. *Intervening scar tissue is removed so that clean, accurately defined edges of skin are present.* The esophageal stoma is opened and trimmed in a similar manner. (G. K. Lewis, M. F. Snitmann and A. Loewy: Ann. Otol., Rhin. & Laryng , Vol. 66)

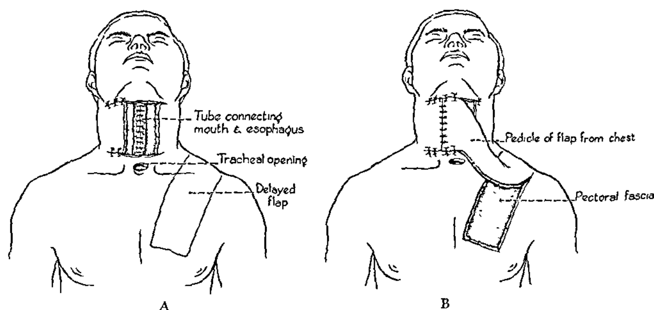


FIGURE 184 *A*, A tube is formed by making 2 vertical paramedian incisions approximately 2 cm from each lateral extent of the pharyngeal opening to a like distance lateral to the esophageal opening The flaps are then undermined medially and rotated to form a tube, skin surface inside The freshened *esophageal mucosa is sutured to the inferior margin* of the tube, using absorbable sutures with knots tied so as to be inside the tube. The freshened edge of the pharyngeal mucosa is sutured to the upper end of the tube in a similar manner *B*, With the new connection formed between the pharynx and esophagus, raw surfaces remaining on the anterior neck must be covered by raising the delayed flap and applying it to the area The pedicle is left attached for 21 days. Feeding is by a nasogastric tube passed through the newly formed esophagus. (G K Lewis, M. F. Snitmann and A. Loewy Ann Otol , Rhin. & Laryng., Vol. 66.)

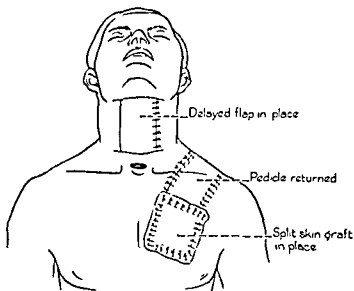


FIGURE 185. After 21 days the pedicle of the flap is cut, and the remaining neck defect is sutured after freshening the skin edges and removing any excess granulations. Unused flap is then returned to the donor site and sutured. Remaining raw area in the pectoral region is covered by a split graft. The nasogastric tube is allowed to remain 10 to 14 days after completion of this stage or until healing is complete, and is then removed. The patient is usually able to swallow with minimal difficulty. (G. K. Lewis, M. F. Snitmann and A. Loewy: Ann. Otol., Rhin. & Laryng , Vol. 66.)

In the male, reconstruction of the cervical esophagus is much more difficult. There are two methods by which this may be accomplished. One method is to fashion out of tantalum mesh gauze a funnel-shaped stent the larger end of which is the diameter of the pharynx, the smaller end the diameter of the esophagus. A large split thickness graft is now cut, using a drum type of dermatome. This is fastened raw side out over the stent (Fig. 181). It is then sutured interruptedly to the mucosa of the pharynx and to the esophagus (Fig. 182). The anterior U-shaped skin flap is then approximated as in the usual laryngectomy, and pressure dressings are applied to cause contact of the split thickness skin graft with the overlying skin for nourishment. This procedure is rather hazardous, since the skin graft is rather large, the vascular bed none too good, and the area potentially contaminated. It is not unusual for some slough of the graft to take place. The tantalum mesh stent must be left in place for many weeks to as long as six months, at which time it may then be removed by grasping it with a forceps through the direct laryngoscope. These types of cervical esophageal repair tend to stenose and require repeated dilatation.

Another method of reconstructing the cervical esophagus utilizes tissues from locally in the neck and skin from the anterior chest as a pedicle graft. This procedure is described in Figures 183, 184 and 185, the captions of which explain the procedure.

OPERATIONS UPON THE TRACHEA

TRACHEOSTOMY

General Considerations

Tracheotomy, or more properly tracheostomy, is an operation in which the trachea is opened and made to communicate via a tube directly with the environmental air for the relief of respiratory tract obstruction above the larynx. More re-

cently the operation has become popular for relief of lower respiratory tract obstruction when this is due to retention of endobronchial secretions, secondary to such conditions as loss of cough reflex from unconsciousness due to head injury, or from paralysis of the muscles of respiration as from poliomyelitis, or from severe trauma to the thoracic wall with rib fractures which may prevent adequate coughing because of pain or because of the paradoxical movements of a flail chest. Depending upon the conditions for which the operation is performed, a tracheostomy may be an emergency procedure done with a minimum of instruments and without regard for surgical asepsis, or it may be accomplished as an orderly surgical procedure. With the widespread use of endotracheal tubes for anesthesia most obstructive disorders requiring an emergency tracheostomy may be converted into nonemergency cases by the passage of an endotracheal tube through the direct laryngoscope. In lieu of an endotracheal tube a bronchoscope may be passed. This should be done whenever practicable. When facilities do not exist for endotracheal intubation or bronchoscopy, then by necessity the emergency type of procedure must be done.

Though an airway may be established much more rapidly by making the incision through the cricothyroid membrane, which is the most superficial point of the respiratory tract, this practice is to be condemned because of the risk of chondritis of the cricoid cartilage which may later result in cicatrization and stenosis of the trachea, preventing removal of the tracheostomy tube later. Tracheal stenosis from this cause is exceedingly difficult to treat.

Dangers and Safeguards

In small infants and children the trachea is small, soft and compressible, so that it is easy to dissect in the paratracheal region behind the trachea and injure the esophagus. Also, because of the smallness of structures, even though the trachea is found and opened, the tracheostomy tube may be inadvertently passed into the paratracheal region where the tissues are loose, so that the tracheostomy tube will not lie in the tracheal lumen and therefore will not relieve the condition for which the operation is being performed. Both difficulties may be prevented by first passing a bronchoscope into the trachea to give it firmness and stability, as well as to relieve obstruction. Bleeding into the incision and into the trachea postoperatively will be prevented by careful hemostasis during the procedure. Should it occur and be severe postoperatively, the wound by necessity will have to be reopened and control of the bleeding point accomplished. In small children and unconscious patients there must be continuous post-tracheostomy observation and/or restraint of the patients to prevent pulling the tracheostomy tube out. Superficial infection in the tracheostomy wound is not uncommon, but serious infections may be prevented by administration of appropriate antibiotics preoperatively and postoperatively. Subcutaneous emphysema may be an annoyance, but is usually not a serious complication and may be prevented by measures to be noted under Postoperative Care (p. 226).

Technique of Emergency Tracheostomy (Fig. 186)

The patient is placed on his back with the neck hyperextended by sand bags under his shoulders. Usually there is no time for any type of surgical preparation or anesthesia The thumb, second and third fingers of the left hand are arched over the

larynx, and the soft tissues of the neck below the larynx are pressed backward on each side of the trachea, tightening the skin and stabilizing the mobile underlying structures. A bold incision is then made vertically in the midline from the cricoid ring downward to the suprasternal notch, cutting through all the pretracheal tissues, including the thyroid isthmus. This should expose the trachea so that the next incision should open the trachea. The trachea is then incised, preferably below the first tracheal ring in a vertical manner. The tracheal incision is held open by forceps, knife handle, retractor or any other instrument available until a tracheotomy tube can be secured and placed in the trachea. As the trachea is opened the patient is turned on his side to prevent blood in the wound from entering the trachea if suction is not available for its removal. Resuscitative measures are then instituted. With respiration established the wound may be packed with gauze to control bleeding if instruments are not available for grasping and ligating bleeding points. As soon as practical, bleeding points should be ligated if they have been previously controlled by packing and the wound loosely sutured. Antibiotics should be administered.

Technique of Orderly Surgical Tracheostomy (Fig. 186)

The patient is placed on his back with sand bags under his shoulders so that the neck may be hyperextended. The field is prepared and draped and local anesthesia instituted by a diffusible injectable agent infiltrated into the soft tissues of the anterior neck. The incision may be either vertical, extending from the cricoid cartilage to the suprasternal notch, or transverse from an anterior border of one sternocleidomastoid muscle to the anterior border of the opposite muscle at a level midway between the cricoid cartilage and the suprasternal notch. The operation will be accomplished more easily through the vertical incision, but a better cosmetic result will be attained through the use of the transverse incision. Another disadvantage to the transverse incision is its tendency to cause downward pressure on the tracheotomy tube so that the tip of the tube is forced backward against the posterior tracheal wall, where it may cause the tube to become obstructed or may cause pressure necrosis or may provoke difficulty in swallowing or stimulate the desire to cough or vomit. If the trans-

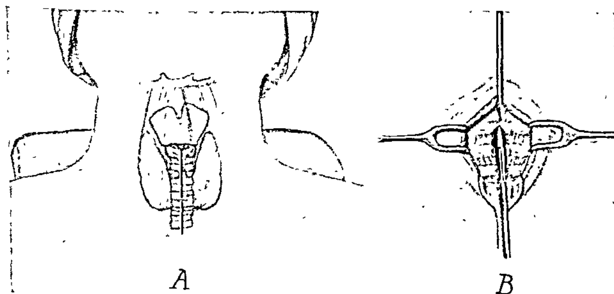


FIGURE 186. *A*, Incisions for high and low tracheostomy *B*, Tracheal rings divided in midline.

verse type of incision is to be used, one must ascertain at the end of the procedure when the tube is in place whether or not the upper flap of the wound will exert downward pressure on the top of the tube. Should this occur, a second, median line vertical incision is made into the upper flap sufficiently large to accommodate the tube and prevent tipping of the outer portion of the cannula downward. The skin incision, whether vertical or horizontal, is carried downward through the platysma muscle and superficial fascia, exposing the sternohyoid muscles, which are split longitudinally in the midline, as are the underlying thyrohyoid muscles if they happen to repose in the midline.

The thyroid isthmus, which has now been exposed, is dissected bluntly from the underlying trachea so that it may be clamped, sectioned and hemostatically controlled by a running mattress suture of 000 chromic catgut. If the thyroid isthmus is low lying or high lying in relation to the trachea, or is narrow, it may be retracted upward or downward to expose the second, third and fourth ring areas of the trachea and will not need to be sectioned. With the trachea exposed it is well to reinspect the operative wound for any bleeding points.

When the operator is ready to open the trachea, suction should be immediately at hand and the tracheostomy tube, with its tapes for tying attached and with its obturator inserted, should be held in readiness by the surgical nurse. The trachea may be stabilized further by placing a hook in the cricoid cartilage with traction upward and outward. A transverse incision is then made with a sharp-pointed knife between the second and third tracheal rings. This incision should extend about 5 mm. on each side of the midline in the adult. Suction is immediately maintained in the area to prevent blood from entering the trachea. Scissors are then introduced through this incision, and in the midline a vertical incision is made downward through the tracheal rings three and four. This T-shaped opening will easily allow the passage in the adult of a number 7 tracheostomy tube. In infants and small children whose tracheas are soft and compressible and will collapse at the slightest provocation, the amount of incision in the anteriort rachea should be kept to an absolute minimum, being made only large enough to barely permit the passage of the proper size tube. If the operation has been accomplished with an endotracheal tube in place, to relieve obstruction, the endotracheal tube is slowly withdrawn to above the opening in the trachea, and immediately the tracheostomy tube is thrust into the trachea. In some short-necked patients the vertical incision may have to be made between the first and second rings. It is preferable not to excise tissue from the tracheal wall. Upon insertion of the tracheostomy tube the wound may be closed. Subcutaneous tissues may be loosely approximated with 000 chromic catgut and the skin loosely approximated with fine silk. Because the wound will be relatively infected, silk or other nonabsorbable material should not be used in the deep portions of the wound. Sterile gauze dressings are applied around the tube, and the tapes which have been previously fixed to the tube are tied at the back of the neck in a hard knot.

Postoperative Care. Secretions should be aspirated from the tube through a number 14 urethral catheter hooked to a suction apparatus. The catheter is compressed at a point where it is fixed to the suction tube so that it will not bind the tracheal wall by suction as it is being inserted. It is then inserted into the tracheotomy tube for a depth of approximately 8 inches in the adult. Compression on the tube is then released

and the catheter slowly withdrawn, the secretions being aspirated as the catheter is removed. This is repeated until no more material is aspirated.

Since the soft tissues of the neck are exposed to tracheal secretions in this procedure, the administration of broad-spectrum antibiotics postoperatively is advised. After about three days the fistula about the tube will be fairly well formed with sealing off of the subcutaneous and fascial spaces so that the patient may inspire through the tube, close it with his finger and expel air through his larynx with some voice production unless the larynx is completely obstructed. This must not be done, however, before this time, since air is apt to be forced out around the tube from the trachea into the fascial and subcutaneous spaces, causing severe subcutaneous emphysema. The inner cannula of the tracheotomy tube may be removed anytime postoperatively as needed for cleaning. The outer tube must not be removed for at least three days until a good fistulous tract has formed. If the outer tube is removed before this time, the tracheal opening may be lost, and it will not be possible to insert another tube into the trachea without resorting to more surgery. If the patient has a complete upper tract obstruction, this may have disastrous results. For the first several times that the outer tube is changed a physician should be in attendance; later its replacement may be trusted to a skillful nurse when the fistulous tract is well formed.

The size of the tracheostomy tube will vary with the age of the patient. In general, the largest tube that can be accommodated should be used, since there will be less soouble postoperatively with the tube obstructing with drying secretions, crusts, and tr on. These secretions may cause objectionable sticking of the inner cannula so that it will be difficult to remove for cleaning. This may be minimized by greasing the outer surface of the inner cannula with petroleum jelly.

Decannulization of the Tracheostomized Patient

When the tracheostomy tube has served its purpose, it should be removed. Some patients seem to develop an attachment for their tracheostomy tubes, especially children, and refuse to permit its removal, even though the obstruction has been relieved. It is also to be remembered that for a variable period of time the patient has not been breathing through his normal upper respiratory passageway, and the sudden reinstitition of breathing through these channels may provoke considerable psychological reaction. It is therefore wise to reduce the caliber of the tracheostomy tube about half for a few days by inserting into the outer end of the tube a small cork which has been cut in half longitudinally. If the patient tolerates this reduction in the size of his tracheostomy tube without difficulty, then the tube may be completely corked. Needless to say, a corked tracheostomy tube in itself is somewhat obstructive of the trachea. If the patient does well with his tracheostomy tube completely corked, then there is little doubt that he would object to the removal of the tube. If after two days, the tube being completely corked, the patient shows no obstruction, it may be removed. The fistulous opening is dressed with petrolatum gauze or dry gauze.

Over a period of several days, this being quite variable, and depending to a considerable extent upon how long the tracheotomy tube has been in place, the tracheal-cutaneous fistula becomes smaller and smaller and may of its own accord seal off completely with healing of the area, leaving only a dense scar. If the tube has been worn for some time, the tracheal-cutaneous fistula may refuse to close completely,

leaving a pinpoint opening from which air will escape on phonation and from which mucoid secretions will exude, soiling the overlying clothing.

If after four weeks the fistula has not obliterated, it should be closed surgically. Again with the patient in the tracheostomy position and by using local anesthesia, the epithelium and cicatricial tissue of the fistulous tract are excised down to the trachea. No attempt should be made to suture the defect in the anterior tracheal wall directly. The superficial layer of deep cervical fascia should be identified by a minimum of dissection to a point at which sufficient tissue can be mobilized to allow it to be approximated over the tracheal defect. Widespread undermining in this area will only open up fascial and subcutaneous spaces which then will communicate with the trachea, setting up ideal conditions for the development of subcutaneous emphysema. After interrupted sutures of the deep layer of cervical fascia with chromic catgut, the superficial fascia is defined by a limited undermining type of dissection and closed interruptedly with catgut. The skin is then closed carefully with fine silk. If desired, a small slip of rubber drain can be placed down to the trachea and removed in about two days. This will minimize the chance of development of emphysema. If a vertical type of incision has been used, it may tend to contract with "fiddle string" deformity. This later may be excised and the scar transplanted horizontally by a Z-plasty type of procedure with improvement in the cosmetic appearance of the neck.

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CHAPTER 9

Thorax and Respiratory System

GENERAL PRINCIPLES

Introduction

A thorough knowledge of anatomy and an understanding of pulmonary physiology are, perhaps, more important to the surgeon doing procedures within the thoracic cavity than in any other segment of the body. Although the principles of "controlled respiration" using intratracheal intubation were understood by the physiologists by the turn of the century and the anatomy of the pulmonary hilum had long been known, it was not until the 1930's that these two vital matters were transposed to the operating room to permit safe and systematic surgical excision of diseased pulmonary tissue. Close teamwork between the operating surgeon and the anesthesiologist is essential. The ready availability of adequate blood replacement must be ensured before starting major chest surgery. The development of antimicrobial drugs has reduced greatly the number of cases of empyema and lung abscess requiring surgical treatment, while this same development has resulted in the ever-increasing applicability of excisional surgery for pulmonary tuberculosis in preference to collapse therapy. The developments in the field of pulmonary surgery since the first successful pneumonectomy by Graham in 1933 have been paralleled by an ever-increasing incidence in lung carcinoma.

Anatomy of the Lungs (Figs. 187, 188, 189)

The concept of the bronchopulmonary segment as the basic anatomic unit was advanced first by Ewart in 1889. In 1942 Jackson and Huber published their own observations along with those of others outlining the usual segmental anatomy of the lungs with a system of nomenclature which has been adopted widely in this country. Overholt and Langer were among the first to emphasize the importance of utilizing the bronchopulmonary segment as the basic surgical unit in excisional surgery.

There are ten segments present on the right and eight on the left, the difference

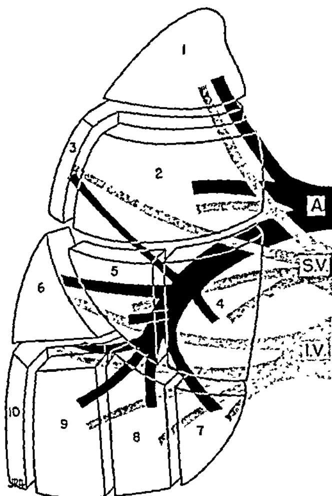


FIGURE 187. Schematic diagram showing the pulmonary segments and vascular pattern of the right lung. *Upper lobe:* 1, Apical; 2, anterior; 3, posterior. *Middle lobe:* 4, medial; 5, lateral. *Lower lobe:* 6, superior; 7, medial basal; 8, anterior basal; 9, lateral basal; 10, posterior basal. (R. H. Sweet: Thoracic Surgery.)

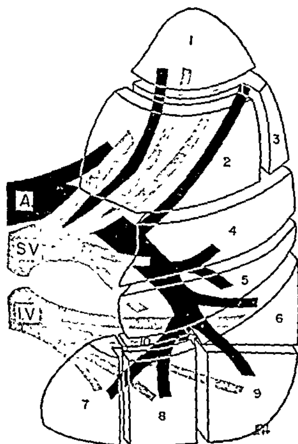


FIGURE 188. Schematic diagram showing the pulmonary segments and vascular pattern of the left lung. *Upper lobe.* 1 and 3, apicoposterior; 2, anterior, 4, superior lingular; 5, inferior lingular. *Lower lobe:* 6, superior; 7 and 8, anteromedial; 9, lateral basal; 10, posterior basal. (R. H. Sweet: Thoracic Surgery.)

being accounted for by a common origin of the apical and posterior segmental bronchi of the left upper lobe as well as the anterior and medial segments of the left lower lobe. From the surgical standpoint, these anatomic subsegments may be regarded as separate segments.

A thorough knowledge of segmental anatomy as well as the arrangements and relationship of the hilar structure and the more common variations is essential. The

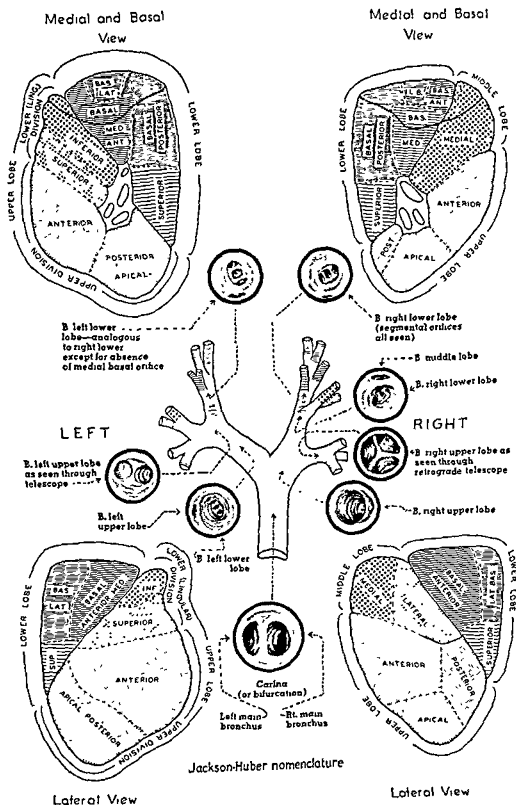


FIGURE 189 Diagram showing the pulmonary segments and tracheobronchial tree as viewed during bronchoscopy (Jackson and Jackson: Bronchoesophagology)

main structures of the primary pulmonary hilum are the main bronchus, the pulmonary artery and the superior and inferior pulmonary veins. The relationships of these structures vary considerably on the two sides. On the left the pulmonary artery curves around the upper lobe bronchus, while on the right side it remains anterior and below the upper lobe bronchus. The segmental arteries follow the segmental bronchi, while the veins occupy an intersegmental position, converging to form segmental veins which in turn empty into the superior and inferior pulmonary veins. On the right side the middle lobe vein empties into the superior pulmonary vein. Variations are common. In general these variations occur in the veins, arteries and bronchi in that order of frequency.

Pulmonary Physiology

The physiology of the thoracic wall and its contents is complex. A few of the essential factors in cardiopulmonary physiology which pertain to operations upon the thorax will be considered here.

A pressure in the pleural space slightly below that of the surrounding atmosphere is essential to maintain the lungs in an expanded state. On inspiration the thoracic cage enlarges by simultaneous expansion of the thorax and downward displacement of the diaphragm with a resultant increase in the subatmospheric intrapleural pressure. The elastic lungs follow the chest wall and diaphragm with a resultant inflow of air into the tracheobronchial tree. As the diaphragm and intercostal muscles relax on expiration, air is expelled from the lungs. Under normal conditions the intrapleural pressure measures approximately -9 to -12 cm. of water on inspiration, and -3 to -6 cm. of water on expiration.

In addition to providing for the elimination of carbon dioxide and the oxygenation of the pulmonary arterial blood, the respiratory cycle also aids in the return of venous blood to the right atrium by virtue of the negative pressure in the thoracic cavity. Any disturbance of this negative pressure mechanism, therefore, not only involves the function of the lungs, but also disturbs the blood flow in the major venous trunks as well as the filling and emptying of the atria.

Pulmonary Function

The lungs perform a dual function: (1) They provide for the reoxygenation of the pulmonary arterial blood, and (2) they provide for the elimination of carbon dioxide. The process of bringing oxygen into contact with the pulmonary blood flow across the alveolar membrane and of moving carbon dioxide out of the alveoli through the tracheobronchial tree is called *ventilation;* the process of transmitting these substances across the alveolar membrane is known as *diffusion.* Any diminution of either ventilation or diffusion may result in improper pulmonary function.

Before doing major chest surgery, an evaluation of the patient's cardiopulmonary reserve is important. Much information can be obtained by a few questions concerning the patient's exercise tolerance as well as a history suggesting early cardiac failure such as orthopnea or dependent edema. Physical examination of the chest to determine the degree of respiratory excursion, the presence of "barrel chest" or other abnormalities as well as cardiac size may be of value. Auscultation may provide knowledge of the degree of pulmonary ventilation. The chest roentgenogram and/or fluoroscopy

may show emphysema, fibrosis or areas of nonfunctioning lung as well as diaphragmatic excursion. In addition, the performance of standard exercise tests such as the climbing of stairs may be an excellent indication of ability to tolerate major chest surgery.

Pulmonary function tests may be necessary to evaluate properly the patient with borderline respiratory reserve clinically. Tests of *diffusion* to determine the rate of exchange of oxygen and carbon dioxide across the alveolar membrane are complex and not generally available. Tests of *ventilation* are generally available and easy to perform, although the results require careful interpretation. Simplification and accuracy of these tests will undoubtedly result from the large volume of research now being done in this field. Figure 190 shows the lung volumes as they appear on a spirographic tracing.

Vital capacity is the maximal volume of gas that can be expelled from the lungs by forceful effort following a maximal inspiration.

Inspiratory capacity is the maximal volume of gas that can be inspired from the resting expiratory level.

Functional residual capacity is the volume of gas remaining in the lungs at the resting expiratory level.

Total lung capacity is the amount of gas contained in the lung at the end of a maximal inspiration.

Tidal volume is the volume of gas inspired or expired during each respiratory cycle.

Inspiratory reserve volume is the maximal amount of gas that can be inspired from the end inspiratory position.

Expiratory reserve volume is the maximal volume of gas that can be expired from the end expiratory level.

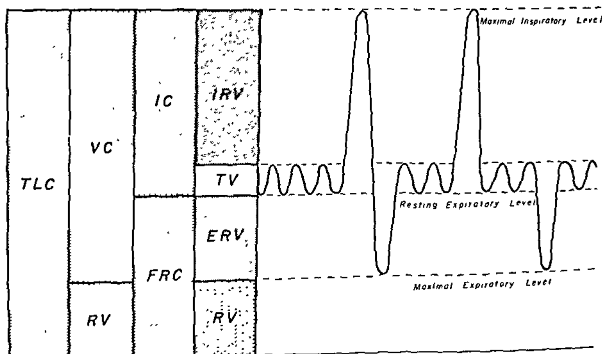


FIGURE 190 Diagrammatic representation of the various ventilatory volumes as they appear on a spirographic tracing. (See text) (J. H. Comroe et al: The Lung. Year Book Publishers, Inc.)

Residual volume is the volume of gas remaining in the lungs at the end of a maximal expiration.

Of the above measurements, the one most commonly used is the vital capacity. In addition, the *maximum breathing capacity* is considered by many to be of great practical value in the evaluation of a patient with pulmonary disease. This is defined as the maximal volume of gas that can be breathed per minute. The test is performed by breathing at the greatest possible voluntary rate and depth for fifteen seconds and the result compared with the anticipated normal based on the patient's age, sex and body surface.

In indicated cases measurement of the function of each lung may be determined by *bronchospirometry* in which specially designed catheters are inserted into the right or left main bronchus.

Anesthesia

Close teamwork between the anesthesiologist and the operating surgeon is required in pulmonary surgery. With the chest open it is necessary to maintain an adequate respiratory exchange, and this is best done by means of an intratracheal tube using a closed or semiclosed system. When the respiratory center and muscles are allowed to remain active and intermittent pressure is applied to the system synchronous with inspiration, it is called *assisted respiration*. When the respiratory center and muscles are rendered inactive and respiration is carried on entirely by the anesthesiologist, it is known as *controlled respiration*. Either method is satisfactory. Automatic machines which deliver the desired amount and pressure of anesthetic gases in a rhythmic fashion are now available.

The choice of anesthetic agent or agents must be determined by the anesthesiologist on an individual basis. In general, the method which provides for the highest percentage of oxygen is desirable. If the electrocautery is to be used, and in many instances this is highly desirable, only nonexplosive agents may be used. In addition to maintaining adequate ventilation, including not only the supplying of oxygen, but also removal of carbon dioxide, it is important to avoid obstruction to the tracheobronchial tree by blood or secretions and to ensure adequate peripheral circulation. Special drugs should be readily available: atropine to depress vagal reflexes, procaine amide to correct cardiac irregularities, norepinephrine to combat peripheral vasodilatation, and epinephrine and calcium chloride for cardiac stimulation.

Position during Operation (Fig. 191)

For chest operations the patient is usually placed in one of three positions: the lateral, the prone or the supine—that is, on the side, face down or face up. Each position has advantages and disadvantages. The lateral position provides the greatest and safest exposure of the hilar structures; however, in this position movement of the nonoperated side is restricted with consequent diminution of ventilatory exchange. There is also danger of spillage of secretions, blood and debris from the affected to the unaffected lung. The prone and supine positions allow optimum cardiorespiratory function and permit better aspiration of the bronchial tree; however, exposure of the hilar structures is more difficult than in the lateral position. Regardless of the position used,

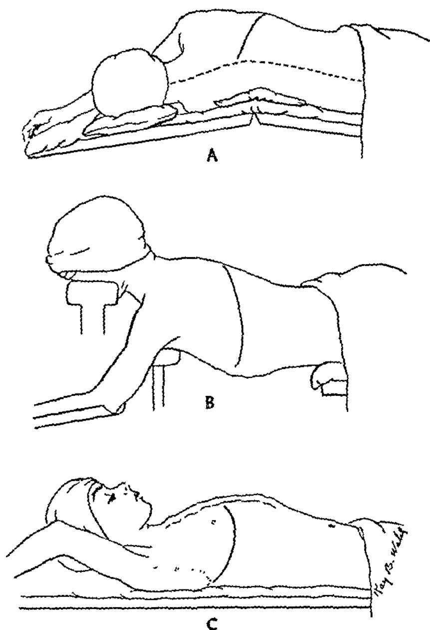


FIGURE 191. Standard positions for thoracotomy, showing the usual direction and location of incision for each position. *A*, Lateral thoracotomy position; *B*, prone thoracotomy position; *C*, supine thoracotomy position.

the head of the table should be slightly lowered to permit escape of secretion and to avoid the danger of air embolism to the cerebral vessels.

Technique of Posterolateral Thoracotomy (Figs. 192 to 196)

As mentioned previously, most intrathoracic operations can be done with maximum ease by using a long incision extending from just below the nipple in front, curving posteriorly below the tip of the scapula and extending slightly cephalad almost to the vertebral column behind. The patient is, of course, lying on his side with the operative side up.

The deep portion of the incision is made either through an intercostal space or through the bed of a rib, depending upon the age of the patient, the amount of exposure required, and to some extent upon the purpose of the operation and the personal preference of the surgeon. In general, removal of a rib affords better exposure and

lessens the danger of fracturing adjacent ribs. In addition, closure of the wound is facilitated.

The incision is made through the skin and subcutaneous tissue, and bleeding points are grasped with fine hemostats. These may be secured with fine ligatures, although the electrocautery is a time saver in this area. Towels are next applied to protect the skin edge. A small incision is then made just behind the posterior edge of the latissimus dorsi muscle at the area of the auscultatory triangle and a cleavage plane beneath this muscle obtained by inserting the finger through this plane.

In order to minimize blood loss when dividing this and other muscles, it is helpful to insert the fingers beneath the muscle and exert pressure outward when cutting the muscle. In this fashion bleeding is controlled by pressure, while hemostats are being applied. The lateral fibers of the trapezius muscle and the fibers of the rhomboid muscles are divided in similar fashion. Since these muscles have no costal attachments, the precise level of division is not important. The fibers of the serratus anterior and externus abdominus oblique muscle have, on the other hand, costal attachments and should not be divided until the rib to be removed or intercostal space to be entered has been determined. The ribs can be accurately determined by passing the hand underneath the scapula and counting from above downward. For operative procedures on the upper lobe, main pulmonary hilum, heart or upper mediastinal region, removal of the fifth rib generally provides the best exposure, while removal of a lower rib may be preferable for procedures on the lower lobe or lower mediastinal structures.

If an intercostal incision is to be made, a short preliminary incision is made

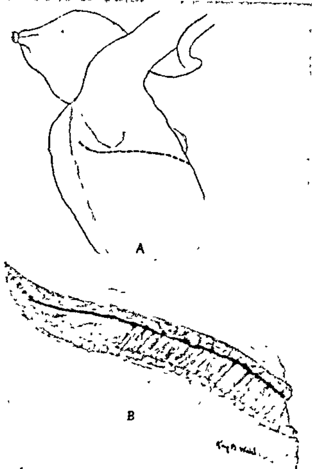


FIGURE 192. Posterolateral thoracotomy. *A*, Skin incision *B*, Incision has been carried through the skin and subcutaneous tissue, revealing the latissimus dorsi muscle anteriorly.

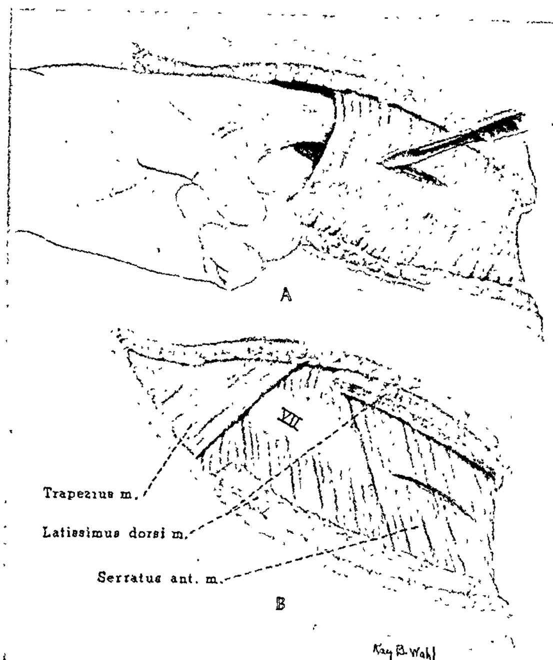


FIGURE 193. Posterolateral thoracotomy (*continued*). *A*, Latissimus dorsi muscle is being divided. By exerting pressure on the muscle as indicated, bleeding can be controlled and clamps applied with minimal blood loss *B*, The latissimus dorsi muscle has been divided, revealing the serratus anterior muscle anteriorly and the border of the trapezius muscle posteriorly. The seventh rib is shown.

midway between the adjacent ribs at any suitable point The pleura is opened and the lung allowed to retract from the thoracic wall. The ribs may be spread slightly by inserting a retractor into the incised area, and the intercostal muscles are then divided with knife or scissors. Since the intercostal bundle lies immediately beneath the upper rib, care must be taken to avoid injuring the intercostal vessels.

When a rib is to be resected, the periosteum is incised from the costochondral junction in front to the neck of the rib posteriorly. Bleeding from the periosteum can be controlled by touching the electrocautery to the knife when the incision is being made. The periosteum is then freed from the rib, using a suitable periosteal elevator. The direction of insertion of the intercostal muscles makes it easier to free the attachments to the edge of the rib by passing the elevator from back to front along the superior margin and from front to back along the inferior margin. The rib is then cut

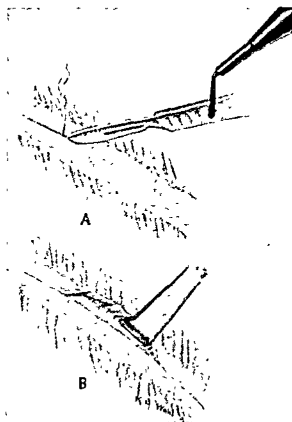


FIGURE 194. Posterolateral thoracotomy (*continued*). *A*, The periosteum of the rib to be removed is incised with the scalpel Bleeding can be minimized by applying the electrocautery to the knife. *B*, Elevation of the periosteum

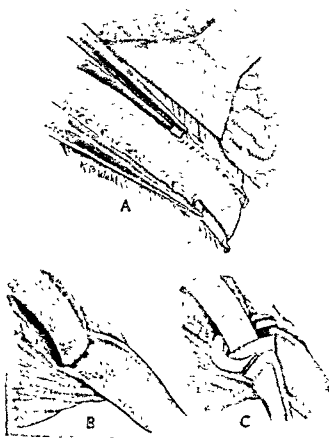


FIGURE 195. Posterolateral thoracotomy (*continued*). *A*, Stripping of the periosteum from the rib margins *B*, Use of the Semb retractor anteriorly. *C*, Division of rib near costochondral junction with a costotome

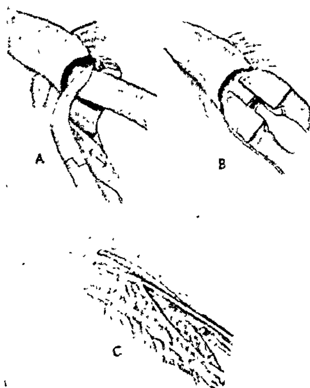


FIGURE 196. Posterolateral thoracotomy (*concluded*). *A*, Division of the rib posteriorly. *B*, Removal of additional rib posteriorly with rongeurs. *C*, The rib has been removed, and the pleura is being divided.

through in front through the cartilage and posteriorly through the neck of the rib. The pleura is then opened along the bed of the excised rib. The wound edges are then protected with moist laparotomy pads and the ribs spread with a suitable mechanical retractor. An additional segment of rib can be removed posteriorly when the chest is partially opened by excising the pleura and periosteum from the inside and removing the rib end with rongeurs after separation of the periosteum. Additional exposure can be obtained by removing a 1-cm. section of one or more ribs above and below posteriorly.

The chest incision is closed by placing interrupted silk sutures in the intercostal muscles adjacent to the rib which was resected. When the sutures have all been placed, the ribs are approximated with a Bailey rib approximator and the sutures are tied. The previously divided muscles, subcutaneous tissue and skin are likewise approximated with interrupted sutures. If haste in closure is required, continuous chromic catgut sutures may be used. Postoperative pain may be lessened by dividing one or more intercostal nerves posteriorly before closure of the chest wall.

Drainage of the pleural cavity following thoracotomy is indicated in most instances. Waterseal drains provide for the removal of accumulating blood and serum as well as the removal of air from the pleural cavity. In addition, re-expansion of the remaining lung tissue is ensured with the preservation of maximum pulmonary function. In most instances both anterior and posterior drainage tubes are used, being brought out through intercostal stab wounds above and below the incision.

After pneumonectomy, drainage of the pleural space is generally not indicated, although a small tube may be left in place to be clamped off and used intermittently for the regulation of pressure within the large remaining pleural cavity. When large areas of denuded lung remain with consequent air leakage, suction not to exceed 15 to 20 cm. of water pressure may be applied to the intercostal drainage tubes. In most

instances the tubes are removed within forty-eight to seventy-two hours following operation.

Dissection, Ligation and Division of Hilar Vessels (Fig. 197)

Individual isolation, ligation and division of the pulmonary hilar vessels is indicated, mass occlusion and ligation rarely being necessary. In dealing with pulmonary vessels several facts must be kept in mind: these vessels are short and cannot be delivered into the wound as in other areas of the body; they carry a lower pressure than peripheral vessels and have thinner and more delicate walls; because of their size, length, location and fragility, injury during dissection may cause massive hemorrhage which is extremely difficult to control, and tears into the vessel wall tend to extend. For these reasons extreme care must be used in dissection, and special methods of ligation are indicated.

The perivascular tissue is picked up, and the adventitial cleavage plane is opened with scissors or by the gentle spreading of a hemostat. Fortunately such a cleavage plane is usually present even when the hilus is involved by dense adhesions and lymph nodes. Once this plane is established, it is developed further by use of clamps, gauze pledgets or finger dissection.

The objectives of proper ligation and division are to place a free ligature and

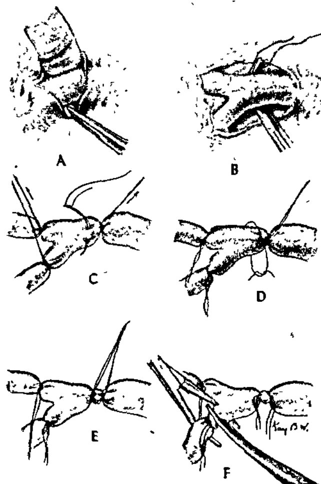


FIGURE 197. Preferred method of dissection and ligation of pulmonary vessels. These vessels are thin-walled and cannot be delivered into the wound, so that care must be taken to avoid serious hemorrhage. (See text.)

suture ligature on the proximal end of the vessel with a cuff 1 cm. in length. If possible, the proximal ligatures are placed on the cardiac side of a bifurcation and the bifurcating vessels divided separately as indicated.

If sufficient length permits, the pulmonary side is also doubly secured to prevent troublesome back-bleeding during subsequent manipulation. If there is to be any *compromise of this method of ligation, it should be made at the expense of the distal* end. A clamp may be applied to the vessels and parenchyma distally to ensure an adequate proximal cuff.

Intrapericardial Ligation of Pulmonary Vessels (Figs. 198, 199)

In certain instances ligation of one or more of the pulmonary vessels inside the pericardium may be indicated. This may be necessary when dissection of the pulmonary vessels in the pleural cavity is difficult or impossible because of extensive inflammatory reaction and fibrosis or encroachment by tumor, or in certain instances in which a vessel is torn close to the pericardium. In addition, routine intrapericardial ligation is a part of radical pneumonectomy as used by some. As the pulmonary arteries leave and the pulmonary veins enter the heart they receive fibrous projections from the fibrous pericardium which blend with their adventitia. When the pericardium is opened usually on a line just posterior to and parallel with the phrenic nerve, the main pulmonary vessels are usually readily visible. The vessels do not lie free within the pericardial cavity, but receive serous pericardial reflections to form

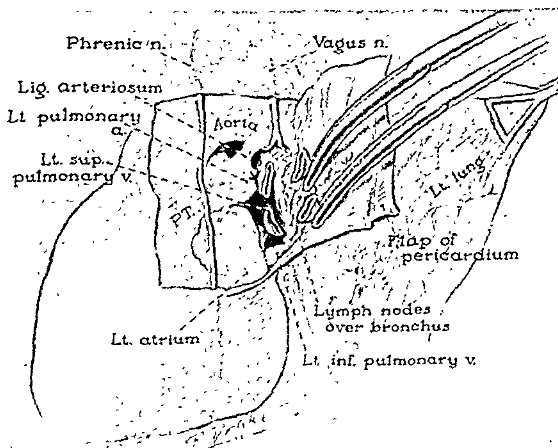


FIGURE 198 *Intrapericardial* ligation of the left pulmonary vessels A flap of pericardium has been reflected to show the relation of the intrapericardial structures The pulmonary artery and superior pulmonary vein have been ligated and divided, leaving the inferior pulmonary vein yet to be isolated, ligated and divided (J. W. Kirklin and R. W Jampolis' J. Thoracic Surg., Vol. 25)

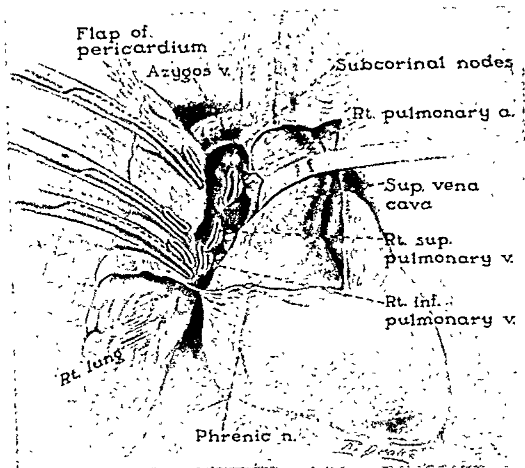


FIGURE 199 Intrapericardial ligation of the right pulmonary vessels. A flap of pericardium has been reflected. The pulmonary vessels are secured by ligature and transfixation ligature proximal and clamped distally before division The superior pulmonary vein must be retracted medially to obtain exposure of the pulmonary artery. (W. H. Wierman, J W. Kirklin and F. H. Ellis· J. Thoracic Surg., Vol. 30.)

short mesenteric-like attachments. These pericardial reflections must be incised to allow a ligature to pass around the vessel. The maneuver is slightly more difficult on the right side because of the overlying superior vena cava. Occasionally it may be advisable to place a fine-toothed noncrushing clamp such as the Potts clamp directly on the vessel near its attachment to the heart and to oversew the vessel after its division rather than to attempt mass ligature.

Division and Closure of Bronchus (Figs. 200, 201)

The bronchial wall consists of a membranous portion and a semirigid cartilagenous portion which prevents collapse of the bronchus and presents a problem in safe closure of the amputated bronchial stump. Several methods of bronchial stump closure have been devised to minimize the danger of early or late leakage with resultant bronchopleural fistula and empyema.

Although variation in the precise method of closure will vary in individual instances, several fundamental principles apply: (1) whether a lobe or the entire lung is being removed, the bronchus should be divided so as to leave the shortest possible stump; (2) in dissection of the bronchus before division, adequate blood supply *must* be retained to ensure a good blood supply by the bronchial arteries; and (3) the application of crushing clamps to the stump should be avoided.

When the bronchus has been isolated, a heavy clamp is placed between the lung tissue to be excised and the point selected for division. This serves as a handle to manipulate the lung, thus facilitating the placement of sutures, and prevents drainage of material from the diseased lung into the tracheobronchial tree or into the operative field.

Medium silk sutures are next placed at each end of the compressed bronchus to serve as stay sutures. Division of the bronchus is then begun (a long-handled knife with the blade at a right angle to the handle may be helpful). Suction should be readily available, and increased pressure should be maintained by the anesthesiologist to avoid drainage into the tracheobronchial tree. After the bronchus has been divided a short distance, usually starting at the edge corresponding to the heel of the occluding clamp, a suture is passed from edge to edge across the divided end. This suture is held without tying. The bronchus is divided further, and another suture is placed. The process is continued until the entire bronchus has been severed. By keeping tension on the sutures, leakage is minimized. Before tying the sutures the divided bronchial stump may be opened for inspection and/or aspiration of secretions. The sutures are then tied tightly enough to coapt the edges, but with care to avoid undue constriction. The cartilage may be divided at each end of the suture line if necessary to obtain satisfactory closure. In most instances the bronchial artery will be picked up in the bronchial sutures, although occasionally a fine suture ligature may be required to control bleeding. Whenever possible, the divided and closed stump should be covered with living tissue. This may consist of peribronchial areolar tissue, a portion of remaining lung or, preferably, a flap of adjacent pleura.

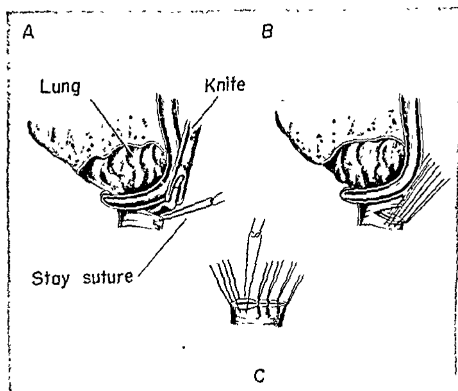


FIGURE 200. Method of bronchial division and closure. *A*, Insertion of stay sutures *proximal* to occluding clamps and beginning of division of bronchus *B*, Bronchus further divided and sutures inserted to be held taut by an assistant to prevent leakage. *C*, Bronchus completely divided and sutures being tied. (R. H. Sweet: Thoracic Surgery.)

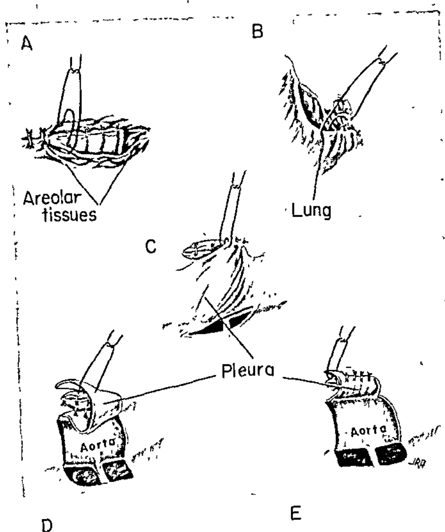


FIGURE 201. Methods of covering the bronchial stump. *A*, Use of peribronchial areolar tissue *B*, Inversion of the stump into contiguous lung tissue after lobectomy or segmental resection. *C*, Use of a sliding flap of pleura *D* and *E*, Use of pleural flaps. (R. H. Sweet: Thoracic Surgery.)

CHEST WALL

TRAUMA OF THE CHEST

General Considerations

Injuries of the chest can be divided into penetrating wounds, usually resulting from gunshot or stabbing, and blunt, crushing injuries such as those sustained in automobile accidents. The primary problem in all chest injuries is the maintenance of adequate ventilation followed by the control of hemorrhage and the repair of damaged tissue.

Ventilation may be interfered with by (1) the accumulation of secretions or foreign material in the tracheobronchial tree; (2) by improper expansion of the chest wall; or (3) by entry of air into the pleural space with resulting pneumothorax.

Wet Lung. The accumulation of secretions or foreign material in the tracheobronchial tree in chest injuries is often referred to as the "wet lung syndrome." The causative factors are (1) the aspiration of blood or vomitus, which occurs frequently after multiple injuries; (2) the increased amount of mucopurulent material due to injury or infection of the lung parenchyma; (3) bleeding into the tracheobronchial

tree following injury to lung parenchyma or bronchioles; and (4) inability of the patient to clear the tracheobronchial tree by coughing, owing to chest pain or concomitant injuries.

In addition to the immediate problem created by a diminution of effective pulmonary ventilation, there is a real danger of atelectasis developing with subsequent infection and lung abscess formation. The patient must be urged to cough and to take deep respirations at regular intervals. When chest pain is present, this must be relieved either by analgesics or by intercostal nerve block when rib fractures are present. Tracheal aspiration may be carried out by means of catheter suction. By passing a rubber nasal catheter into the trachea, coughing is stimulated and any accumulated secretions can be effectively removed by suction. Steam inhalations and wetting agents may be of value. Mechanical coughing machines are available. Bronchoscopic aspiration may be necessary. If the foregoing measures prove ineffective or are too exhausting to the patient, tracheostomy should be performed. This not only permits frequent effective aspiration of the tracheobronchial tree, but also improves the ventilatory efficiency by lowering the resistance to inspiration and expiration and by decreasing the respiratory dead space, although effective coughing is difficult with a tracheostomy tube in place.

Paradoxical Motion. When the integrity of the chest wall is lost—as, for example, in the presence of multiple rib fractures—that portion of the chest wall may be seen to move inward on inspiration and outward on expiration. This paradoxical motion resulting from the so-called flail chest reduces ventilatory efficiency not only by the loss of function of the involved lung, but also by virtue of the fact that a certain amount of air moves back and forth from one lung to the other during the respiratory cycle. In addition, there may be difficulty in the removal of tracheobronchial secretions with resultant wet lung syndrome. Many such injuries also are accompanied by various degrees of pneumothorax. Lesser degrees of flail chest may be controlled by the application of a sand bag to the involved area or by the construction of a rigid splint made of gauze pads, rubber sponges or tongue depressors held tightly against the flexible area with adhesive strapping. When pulmonary function is low or when a large area of the chest wall is involved, the application of skeletal traction may be indicated. This is done by grasping one or more ribs of the involved area with towel clamps or by stainless wire passed around the rib under local anesthesia and applying traction as necessary by means of a pulley and weights.

Open Pneumothorax

Open pneumothorax resulting in a sucking wound is frequently produced by a wound that penetrates the chest wall. Open pneumothorax is dangerous and is likely to result in speedy death unless promptly corrected. The danger is not always in direct proportion to the size of the opening in the chest, but, according to Graham and Bell, depends to some extent upon the patient's vital capacity. If the vital capacity is low and the tidal air is almost equal to the vital capacity, a small chest opening might not be long survived. If, before an injury, the pleural cavity has been partially or completely obliterated by adhesions, as a result of pneumonia, empyema or other inflammatory disease, the danger of an open wound of the chest is greatly reduced.

If a large opening is made in the chest wall, the lung on the affected side col-

lapses. It is well established that the effects of an open pneumothorax under normal conditions are not confined to one side, but are evident on both sides. The capacity of the opposite lung is decreased, and the pressure in the closed thoracic cavity is increased. The movement of the collapsed lung becomes paradoxical in that it expands with expiration and collapses with inspiration. Such respiratory movements cause a flow of air from one lung to the other, resulting in a greatly diminished oxygen content of the alveolar air and, consequently, diminished oxygen in the blood. An open pneumothorax also exerts a serious effect upon the heart and great vessels by the shifting or "fluttering" of the mediastinum with inspiration and expiration.

Closed Pneumothorax

Closed pneumothorax is much better tolerated than an open pneumothorax. This usually results from injury to the lung parenchyma or bronchial tree from a penetrating wound or from laceration by the sharp end of a fractured rib or clavicle, thus permitting air to accumulate in the pleural cavity. The mechanism involved and the principles of management are much the same as those occurring in spontaneous pneumothorax, which usually results from the rupture of a small subpleural bulla or bleb. The degree of air in the pleural cavity may vary from an amount barely visible on roentgenogram and not detectable on physical examination to continued accumulation of air with a build up of pressure sufficient to displace the mediastinum to the sound side with resultant disturbance of the heart action and diminution of respiratory function producing death from asphyxia or rupture of the mediastinal structures, a *tension pneumothorax.* Small degrees of pneumothorax usually require no treatment. Moderate degrees of pneumothorax may be corrected by needle aspiration either with a syringe or by using a pneumothorax machine. When this proves ineffective or there is a repeated accumulation of air in the pleural cavity, closed thoracostomy and the establishment of waterseal drainage are indicated.

In the presence of serious respiratory embarrassment a needle, preferably of a large bore, inserted into the pleural space may be lifesaving. Since the pressure in the pleural space is greatly elevated, air will escape with a rush through the needle with temporary improvement of symptoms. The establishment of waterseal drainage by means of closed thoracostomy should then be instituted.

Closure of Open Chest Wounds

An open or sucking chest wound should be closed promptly, thereby converting an open into a closed pneumothorax. It is important that the potential seriousness of a chest wound be recognized early, even though the wound appears relatively innocent and the condition of the patient is good. Shock may dominate the picture and require prompt treatment. Often the patient suffers from "thoracic shock" caused by a specific imbalance of the vital functions of respiration and circulation within the chest (Alexander).

As an emergency procedure, closure of a chest wound may be effected with a moist pack, petrolatum gauze or rubber sheeting to prevent ingress of air. If the wound is large, the patient should be sent to the operating room, where a careful cleansing of the wound and débridement can be done. Any hemorrhage from the intercostal or internal mammary vessels should be controlled. The wound in the chest is snugly

closed with silk or catgut sutures in the muscle and fascia and silk sutures in the skin. Immediate drainage of the chest is not indicated. Positive pressure anesthesia is advised to reduce shock and to expand the lung as the wound is closed. Air may be aspirated after the wound has been closed. A pressure dressing is applied.

Technique of Closed Thoracostomy (Figs. 202, 203)

The second or third intercostal space in the midclavicular line is usually the preferable site of introduction of the catheter. After routine skin preparation the skin,

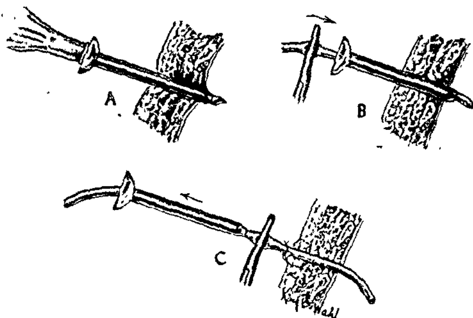


FIGURE 202. Technique of closed thoracostomy, illustrating the introduction of a catheter into the pleural space through a trocar inserted through an intercostal space. The catheter is fixed to the chest wall and attached to a waterseal drain.

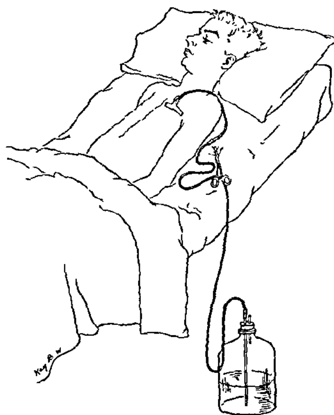


FIGURE 203 Method of attaching pleural catheter to waterseal drainage The connecting tube is attached to the glass tubing, which reaches below the water level in the bottle, and all connections should be doubly checked.

subcutaneous tissue and intercostal muscles are infiltrated with local anesthetic agent. A small transverse incision, just large enough to accommodate a trocar and cannula, is made through the skin. The trocar and cannula are then plunged into the pleural space, the trocar then withdrawn and the catheter passed into the pleural space through the cannula. The cannula is then withdrawn over the catheter and the catheter fixed to the skin with a suture. A small dressing is applied, and the catheter is further secured to the skin with adhesive. The catheter is then attached to a long rubber tube the end of which extends to a bottle below the bed and is immersed in water to make a waterseal drainage. The air in the pleural space will thus escape through the waterseal drain and allow for re-expansion of the lung. Strong suction is to be avoided because of the danger of reopening the injured lung tissue. After the lung has been completely re-expanded and leakage of air has ceased for thirty-six hours, the catheter may be safely withdrawn.

Hemothorax

Hemothorax may be produced by wounds of the intercostal vessels, vessels within the lung, or major vessels at or near the hilum of the lung. Bleeding into the pleural cavity is frequently self-limiting, owing to compression of the lung as the blood accumulates. If sufficient blood accumulates in the thoracic cavity, the hydrostatic pressure will displace the mediastinum, causing circulatory and respiratory embarrassment and decompensation.

Technique of Operation. If a large quantity of blood accumulates in the pleural cavity before pressure closes the bleeding vessel, cardiorespiratory embarrassment may develop rapidly. In such cases aspiration of 200 to 300 ml. of blood will usually give prompt relief. Recurrence of bleeding may occur, but, according to Carter and DeBakey, this is the exception rather than the rule, except when the bleeding is from the chest wall. These authors state that early and repeated aspiration for hemothorax is the procedure of choice and has the following advantages: (1) it relieves high intrapleural pressure; (2) it removes an excellent culture medium; (3) it aids in early expansion of the lung and limits the area of empyema if infection develops; (4) it decreases the incidence of massive clotting; and (5) it prevents the late fixation and contraction of the thorax. Aspiration should be repeated every day or two until the pleural cavity is freed of blood and serum. Injection of air to replace the aspirated blood is not recommended, since air collects at the apex of the pleural cavity and prevents expansion and adherence of the upper lung to the thoracic wall. If infection develops, lack of expansion and adherence of the upper portion of the lung will increase the extent of an empyema.

Clotting of blood does not usually occur in the pleural cavity unless there has been extensive tissue damage. When only small quantities of blood can be aspirated, and the x-ray and clinical findings of blood in the pleural cavity persist, clotting should be suspected. The use of fibrinolyzing agents such as streptokinase-streptodornase or Tryptar as chemical decorticants may be of value. When blood clots in the pleural cavity, operation is indicated for removal of the clots and the layer of fibrin which forms over the lung. In the late cases, if the lung will not expand after removal of the clots and fibrin, decortication of the lung is indicated. The thoracic wound is completely closed, and waterseal drainage is established.

Technique of Decortication for Hemothorax (*Figs. 204, 205, 206*). One of the important advances in thoracic surgery during World War II was the rediscovery and reapplication of pulmonary decortication by Churchill, Blades, Samson, Burford and others.

The incision should be planned somewhat according to the extent and location of the organized hemothorax. In general, the classic posterolateral incision with removal of a segment of rib is preferable. In the simple noninfected case the enveloping rind is entered directly by incising through the parietal segment, and the central contents are evacuated. A small incision is made through the visceral segment of the peel, taking care not to injure the underlying lung parenchyma. Positive pressure by the anesthesiologist may be helpful in thus establishing a cleavage plane between the peel and the visceral pleura. By using sharp and blunt dissection the peel is gradually removed from the entire area of involved lung. The ease with which this is accomplished varies tremendously from case to case. In some instances gentle traction and finger dissection through a clean cleavage plane can be accomplished with ease. In other instances sharp knife dissection is necessary. In the latter type of case, injury to the underlying visceral pleura and lung parenchyma is inevitable with air leakage and hemorrhage; however, with gentleness of technique and patience on the part of the operator, such injury can be kept to a minimum.

As the dissection advances from the visceral to the parietal peel in the area where the peel is reflected onto the chest wall, there will be an obliterated space where both pleural surfaces are together. This area will, of course, be of varying distances from the hilum. In some instances it may be advisable to enter this space first and perform the decortication from the hilum anteriorly. It is important to carry the decortication down into the interlobar fissures and to dissect the peel from any enfoldings of the lobes which may be present. When the peel is laminated, it is important to remove all layers of peel to ensure adequate re-expansion of the lung. The diaphragm is then decorticated so far as possible and the costophrenic sulcus redeveloped. The remainder of the parietal peel is then removed from the chest wall. This is not considered necessary by some in cases of simple, noninfected, organized hemothorax. However, if the



FIGURE 204. Decortication for organized hemothorax or empyema The chest has been opened and a segment of the fifth rib removed. The cavity of the organized hemothorax has been entered by incising directly through the parietal peel, and the contents have been evacuated. A small incision is made in the visceral portion of the peel, and a cleavage plane between this and the visceral pleura has been developed by sharp dissection. (P. W Sanger. Surg., Gynec & Obst, Vol 82)

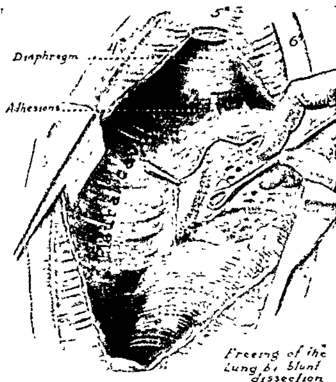


FIGURE 205. Decortication for organized hemothorax or empyema, illustrating the method of removing the organized exudate from the compressed lung by blunt dissection Care must be taken not to injure the visceral pleura and underlying lung parenchyma, but all layers of the membrane must be removed. (P. W. Sanger: Surg., Gynec. & Obst., Vol. 82.)



FIGURE 206. Decortication for organized hemothorax or empyema, showing the lung being re-expanded after removal of the membrane. The entire lung, including the interlobar fissures, must be freed from the enveloping membrane, and, if full ventilatory function is to be obtained, the parietal portion of the peel must be removed from the diaphragm and chest wall. (P. W. Sanger: Surg, Gynec. & Obst, Vol 82)

chest wall proper is to regain its function, removal of this thickened peel is advisable. The parietal peel usually separates with ease, owing to the fact that the parietal pleura is removed along with the peel.

After complete decortication the lung should fully expand to fill the pleural space. The pleural cavity is then irrigated well and an attempt made to close any air leaks in the lung parenchyma which appear large enough to be troublesome. The chest wall is closed in layers after the insertion of anterior and posterior drainage tubes for waterseal drainage. These procedures may be time consuming, and preparations for replacement of considerable blood loss should be made.

Foreign Body in Lung

Foreign bodies in the lung causing symptoms should be removed. Infection may develop about a foreign body, especially if portions of clothing or other material are carried into the chest with the foreign body. Samson and associates recommend thoracotomy between the fourth and tenth days after injury. Such a period of time before operation permits pulmonary recuperation and facilitates palpation of metallic fragments in crepitant aerated lung tissue.

Technique of Removal of Foreign Body from the Lung. The usual precautions necessary for operation with an open pneumothorax must be observed. Positive pressure anesthesia is used. A lateral or posterolateral incision made over the fourth to the seventh rib will usually afford adequate exposure. It may be necessary to resect a rib. After freeing adhesions the lung tissue is carefully palpated to locate the foreign body. The portion of the lung involved is incised, and the foreign body is removed. If an abscess has developed, its wall should be excised. The wound in the lung is closed with silk. The lung is expanded by positive pressure, and the wound in the chest wall is closed with interrupted sutures of silk. Intercostal waterseal drainage is advised.

CHONDRITIS AND PERICHONDRITIS

General Considerations

Infection of the costal cartilages may be due to the tubercle bacillus, typhoid bacillus, *Treponema pallidum*, the fungus of actinomycosis, or pyogenic bacteria. Such infections are characterized by their chronicity. Operation is usually indicated for such infections.

Dangers and Safeguards

Surgical treatment of infections of the costal cartilages is frequently unsatisfactory, and repeated operations may be necessary to effect a cure. Antibiotic therapy should be combined with surgery.

Anatomical structures of importance are the pleura, pericardium, mediastinum and internal mammary arteries. Careless surgery may introduce infection into the spaces noted, or serious hemorrhage may result from wounding an internal mammary artery.

Technique of Operation

Except in early cases, one or more sinuses are often present, associated with much induration of tissues. Local anesthesia is usually less satisfactory than inhalation gas anesthesia.

An incision is made directly over the suspected infected cartilage, and all sinuses are connected by incisions. Sinus tracts are excised. The entire costal cartilage involved is excised from the sternum to the costochondral junction. Any remaining portion of cartilage is likely to cause a persistence of the infection. If the pleura or pericardium is opened by accident, it should be immediately closed with sutures. After carefully ligating all bleeding vessels with fine catgut, the skin may be closed

with silk. Drainage should be used in most cases. If the infection is due to tuberculosis, the wound may be closed without drainage unless it is secondarily infected.

OSTEOMYELITIS OF RIBS AND STERNUM

General Considerations

Types of infection found in the ribs and sternum may be similar to those involving the costal cartilages. Such infections may be primary, but they are most frequently secondary to wounds, compound fractures, or operations.

Dangers and Safeguards

As in operations upon the costal cartilages, injury to the pleura, pericardium and mediastinum must be avoided. Below the pleura the diaphragm lies close to the ribs, exposing it to injury with possible peritoneal infection. The intercostal vessels and nerves may be wounded. Open pneumothorax is to be avoided. The resultant disturbance of thoracic physiology with its accompanying dangers is discussed on page 246.

Technique of Operation

In the acute stage, incision and drainage are indicated. As in osteomyelitis elsewhere, complete removal of sequestra is necessary in the chronic stage. Sinus tracts should be opened and excised. Simple drainage with partial wound closure is usually sufficient in most cases. In tuberculous infections not secondarily infected, the wound should be closed without drainage.

TUMORS OF THE CHEST WALL

General Considerations

In general, radical excision is the logical treatment for most tumors of the chest wall. Radiotherapy should be considered an adjunct treatment in those cases not curable by operation. Demonstrable metastases usually contraindicate operation.

Dangers and Safeguards

Since tumors of the chest wall vary widely in type, size and location, the possible dangers of operation must necessarily vary within wide limits. Shock, bleeding, pneumothorax and infection are the most frequent complications. The development of extensive mediastinal or subcutaneous emphysema may be avoided by carefully avoiding injury to the lung and by airtight closure of the thoracic wound.

In a series of 175 recorded cases subjected to radical operation, Heuer and Andrus report an immediate mortality rate of 20 per cent. The late results of operation depend upon the type of tumor and the thoroughness with which the tumor is removed. On the whole, the percentage of complete cures in the malignant cases is low.

Technique of Operation

A gas anesthetic with equipment for positive pressure is the choice. Local anesthesia is satisfactory in many cases when the pleural cavity is not to be opened.

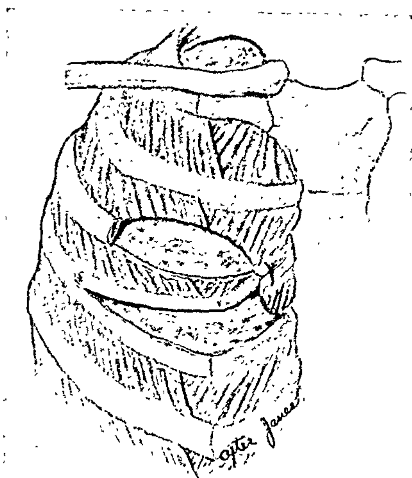


FIGURE 207. Method of repair of opening in chest wall after removal of tumor. (After Janes: J. Thoracic Surg)

The skin incision is made over the tumor in such a manner that sufficient skin and subcutaneous tissues will be available to make an airtight closure after a portion of the chest wall is excised. In rare instances, flaps of skin, muscle or the female breast may be used to close thoracic wall defects. The tumor should be removed with a wide margin of surrounding tissue. This tissue may include the ribs and pleura and, in rare cases, portions of the lung or diaphragm. The extent of the resection will depend upon the patient's condition. All bleeding points must be carefully ligated or sutured.

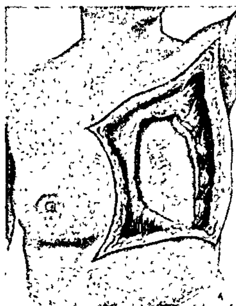
An airtight closure of the thoracic wall is made by careful suture of skin and soft tissues of the chest wall. In rare instances the lung may be sutured to the margins of the defect to aid in the airtight closure. To produce a stable chest wall, Janes has split a rib with a motor saw to bridge the defect (Fig. 207). Half of the sternal end of the split rib is divided. By lifting the upper half, a greenstick fracture is produced at the posterior end. The distal cartilage is removed and the anterior end secured in its bed with a chromic catgut stitch. The soft tissues are securely closed over the defect. Before closing the wound snugly, the lung should be gently expanded by positive pressure, or the air may be aspirated from the thoracic cavity after wound closure.

Other methods of reconstruction of the chest wall, after removal of recurrent carcinoma of the breast, have been described by Pickrell, Baker and Collins. Figures 208, 209 and 210 show a large defect in the chest wall which has been closed by suturing the pericardium to the fascia covering the sternum and intercostal muscles and

the application of large skin grafts in the skin defect. In Figures 211 and 212 a second technique is illustrated which has been used to close an opening in the chest wall with a pedicled skin flap.

In selected cases a pendulous breast may be mobilized to fill a defect in the chest wall. When this operation is done, a broad pedicle containing adequate blood supply must be preserved to prevent necrosis of the breast. Wire mesh, Fiberglas cloth or other prosthetic materials may be used to fill large defects in the chest wall.

Fig 208.



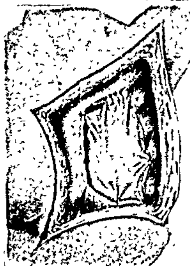


Fig 209.

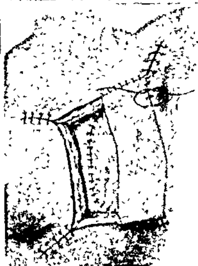


Fig 210.

FIGURE 208 Defect in chest wall after wide excision of recurrent carcinoma of the breast. Part of the sternum and parts of the third, fourth, fifth, sixth and seventh ribs have been resected. The pericardium and left pleural cavity are exposed. (Pickrell, Baker and Collins: Surg , Gynec. & Obst. By permission of Surgery, Gynecology and Obstetrics.)

FIGURE 209. The pericardium has been sutured to the fascia of the sternum and intercostal muscles to form a surface for skin grafting The heart was lifted forward by this procedure without any ill effects (Pickrell, Baker and Collins Surg., Gynec. & Obst. By permission of Surgery, Gynecology and Obstetrics)

FIGURE 210. The defect has been partially closed by suturing the angles. Two heavy split grafts were used to cover the defect, which measured 8 by 9 inches. (Pickrell, Baker and Collins: Surg., Gynec. & Obst. By permission of Surgery, Gynecology and Obstetrics.)

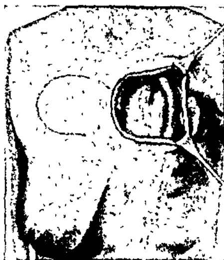

Fig 211.


Fig. 212.

FIGURE 211. Recurrent carcinoma of the breast removed by resecting a portion of the sternum and parts of the second and third ribs. The great vessels at the base of the heart were exposed. A flap on the right chest wall is outlined. (Pickrell, Baker and Collins: Surg., Gynec. & Obst. By permission of Surgery, Gynecology and Obstetrics.)

FIGURE 212. The chest wall defect has been closed with a broad pedicled skin flap from the right chest wall. Two rows of interrupted silk sutures were used. By drawing the right breast upward the donor defect could be closed (Pickrell, Baker and Collins: Surg, Gynec. & Obst. By permission of Surgery, Gynecology and Obstetrics.)

THORACOPLASTY

General Considerations

Collapse of the chest wall by removal of ribs may be necessary as a part of the management of pulmonary tuberculosis, or it may be necessary to eliminate an unfilled pleural space created by the removal of lung tissue as in lobectomy or failure of the lung to fill the thoracic cavity for other reasons. During the past decade the indications for thoracoplasty have decreased sharply as a result of the efficiency of specific antituberculosis drug therapy. With the aid of the antimicrobial agents more cases of pulmonary tuberculosis can be managed successfully without the aid of surgical intervention, and also, the use of these drugs has permitted extirpation of lung tissue involved by tuberculosis with safety. As the number of cases requiring thoracoplasty has decreased, the number of cases suitable for segmental resection or lobectomy has increased. However, there are many patients not suited for extirpative surgery who obtain benefit from thoracoplasty. In addition, thoracoplasty may be indicated as an adjunct to extirpative surgery either to eliminate pleural dead space or to prevent overexpansion of the remaining lung tissue.

Thoracoplasty is a destructive type of operation and, because of its danger and resulting deformity, is not to be considered lightly. Patients considered for this operation should be carefully selected by close cooperation between the phthisiologist and surgeon. To maintain an operative mortality rate within reasonable limits, a careful study of the patient's operability is made in each case. The extent of each operative procedure must be limited to the patient's tolerance. Multiple-stage operations are done when extensive thoracoplasty is necessary.

In general, thoracoplasty is applicable to patients having unilateral cavitation.

Bilateral procedures are usually to be avoided. Patients between the ages of fifteen and forty-five offer the best surgical risks. Lesions of the fibroid type, which present evidence of healing, are to be chosen for operation. Graham states that the best subjects are those who have demonstrated ability to help themselves by evidence of healing, indicated by deformed trachea, narrowed intercostal spaces, elevated diaphragm and absence of active tuberculosis elsewhere in the body. Archibald tersely remarks that a patient with a tendency to activity and no tendency to fibrosis is no fit subject for thoracoplasty. He further states that the problem is much more biological than anatomical, and our chief concern should be to establish an exact accounting of the patient's general resistance.

Dangers and Safeguards

Thoracoplasty is contraindicated in those patients who are generally in poor condition with active exudative lesions in either lung, active extrapulmonary lesions or severe myocardial or renal disease. The operation should not be attempted as a last resort in patients who are obviously dangerous risks. The mortality rate will be in direct proportion to the care with which patients are selected for operation. Archibald has reported an operative mortality rate of 11.6 per cent.

The chief immediate danger of operation is *shock*. This usually can be avoided if careful attention is given to minimizing trauma and to control of all bleeding. Blood replacement should be ready in all cases.

Paradoxical respiratory movements after rib resection lead to respiratory and cardiac embarrassment. Accidental puncture of the pleura or adherent lung may result in tuberculous wound infection or empyema. Pleural puncture is particularly likely to occur near the spine when freeing the neck of the rib. By placing the patient in a 15-degree Trendelenburg position, bronchial secretions can be more easily evacuated and dissemination of tuberculous material minimized.

Alexander states: "The performance of a modern posterolateral thoracoplasty includes the following important technical elements: (1) Operation in the Trendelenburg position; (2) multiple stages, approximately three weeks apart; (3) resection of no more than three ribs at any one stage, and usually only two or two and a half ribs; (4) removal of the uppermost ribs first; (5) retention of lower ribs that do not lie over important lesions; (6) resection of great lengths of the ribs and the transverse processes of the vertebrae at the level of the cavity, as well as above and somewhat below the cavity and other extensive lesions, but retention of the cartilages and extreme anterior ends of the ribs unless the pleura is rigid; (7) removal, if necessary, of appropriate cartilages and anterior costal stumps at an anterior stage; (8) formalization of certain sections of the decostalized periosteum; (9) preoperative and postoperative aspiration of air and fluid that may be present in the pleural cavity and, if necessary, aspiration during operation; (10) performance of the operation gently and expeditiously but without haste."*

Technique of Extrapleural Posterolateral Thoracoplasty

The patient is placed on the table with the diseased side up, held in position with sandbags and straps or by special table attachments such as those designed by

* From John Alexander: The Collapse Therapy of Pulmonary Tuberculosis, p. 493. Courtesy of Charles C Thomas, Publisher.

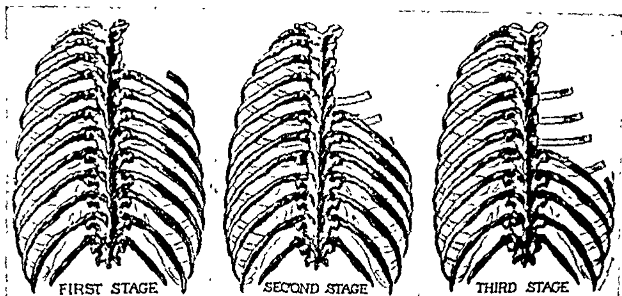


FIGURE 213. A type of modern thoracoplasty operation. First stage: All of the first rib and cartilage and part of the transverse process of the vertebra, the posterolateral portion of the second rib and all of the second transverse process and a part of the posterior portion of the third rib and all of the third transverse process are removed in this stage. Second stage: The remaining posterolateral portion of the third rib, the posterolateral portions of the fourth and fifth ribs and all of the fourth and fifth transverse processes are removed. Third stage. The posterior and parts of the lateral portions of the sixth and seventh ribs and all of the sixth and seventh transverse processes are resected (Alexander: The Collapse Therapy of Pulmonary Tuberculosis, Charles C Thomas)

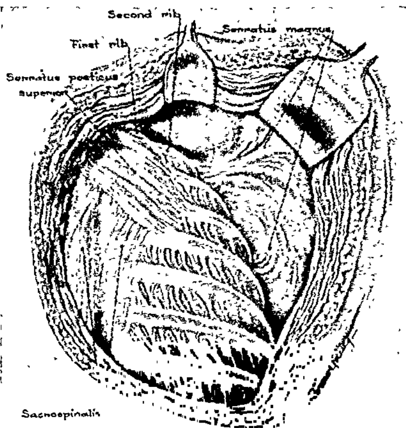


FIGURE 214 *Technique of posterolateral thoracoplasty* The scapula is being retracted posteriorly and laterally, putting the upper portion of the serratus magnus muscle under tension. Muscle attached to second rib aids in its identification (Alexander The Collapse Therapy of Pulmonary Tuberculosis, Charles C Thomas)

Ockerblad. The head is lowered so that secretions from the lung cavity or bronchi will drain away from the opposite lung. The arm is drawn forward to displace the scapula as much as possible from the spine.

First Stage (*Alexander's Method*) (Figs. 213, 214, 215). The incision is begun 5 cm. posterior and inferior to the anterior border of the trapezius muscle and extends

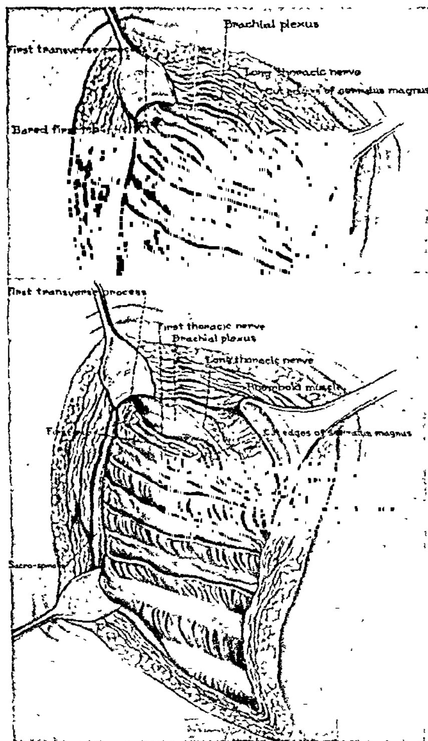


FIGURE 215. Technique of posterolateral thoracoplasty. The origins of the serratus magnus muscle have been separated from the upper 5 ribs This permits easy retraction of the scapula In the upper drawing the posterolateral portion of the second and third ribs has been resected, and the first rib has been freed of its periosteum The lower drawing shows removal of the first 4 ribs completed. The entire first rib is resected with its cartilage All of the transverse processes of the vertebrae and necks of the ribs, except the first, are resected Usually only two, two and a half or occasionally three ribs are removed at one stage. (Alexander J Thoracic Surg Courtesy of C. V. Mosby Company.)

downward mesial to the vertebral border of the scapula and curves outward below the angle of the scapula to the midaxillary line. All tissues are severed down to the ribs. The vertebral border of the scapula is then lifted and easily separated from the chest wall, exposing the origins of the serratus magnus muscle attached to the upper five or six ribs. These attachments are severed to permit good exposure of the first and second ribs. The second rib (or second and third ribs if a three-rib resection is planned) is freed of its periosteum and removed from the transverse process to the costochondral junction. The third rib may be half removed and a further portion excised at a second stage. The first rib is removed in its entirety, including half or all of the costal cartilage. Half of the first transverse process, with its underlying rib, and all of the second and third transverse processes, with underlying sections of ribs, should be removed to permit maximum collapse of the lung in the costovertebral gutter. To prevent regeneration of ribs, the exposed periosteum of each resected rib is dried and rubbed with 10 per cent formalin. This treatment with formalin should extend from the transverse processes to the axillary border of the scapula and throughout their entire length if the anterior pleurae and lung are rigid. The muscle layers are closed with catgut and the skin with silk. If hemostasis is complete, drainage will not be necessary. A light pressure dressing is applied.

Second Stage. Approximately three weeks after the first stage, the old scar is excised, except the upper portion over the first and second ribs. The muscles are again incised as in the first stage. The fourth and fifth ribs with their transverse processes and any remaining portion of the anterior two thirds of the third rib are removed to about the anterior axillary line. The length of each rib removed decreases from above downward (Fig. 213). The subscapular portions of the periosteum are formalized. Drainage from beneath the scapula through the lower end of the incision is advised for twenty-four to forty-eight hours. The wound is closed as in stage one.

Third Stage. The lower end of the scar is again excised and the ribs exposed. If more than seven ribs are to be removed, a new incision should be made extending downward from the former scar. The sixth and seventh ribs are excised to the anterior axillary line and treated as above.

The length and number of ribs removed depend upon the extent of the lung lesion. The foregoing technique is applicable to the average case. Anterior thoracoplasty as described below may be necessary to close some extensive pulmonary cavities.

Technique of Anterior Thoracoplasty (Haight) (Figs. 216, 217)

Alexander makes the statement that anterior thoracoplasty is an indispensable and highly effective operation for residual cavities that may remain after an extensive, properly performed, posterolateral thoracoplasty. It should not be used as a preliminary operation.

A semicircular incision overlying the anterior axillary fold external to the breast is used. It extends from 2 to 3 cm. mesial to the axillary fold downward and divides the lateral 3 or 4 cm. of the pectoralis major muscle. The axillary fascia is divided, the pectoralis major is retracted inward, and the origins of the pectoralis minor are freed from the ribs The arm is abducted and mesially flexed at the shoulder to relax the

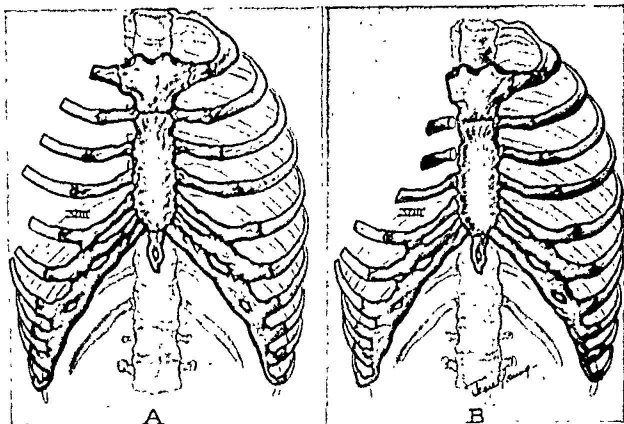


FIGURE 216. Complementary anterior thoracoplasty *A*, Diagram illustrating the extent of the posterior resection before a contemplated anterior thoracoplasty. *B*, The anterior costal stumps (second, third and fourth) and the first costal cartilage have been resected at the anterior stage. Second and third cartilages have been divided at their sternal attachments, allowing them to swing mesially and posteriorly to increase anterior collapse (Haight· J Thoracic Surg., Vol. 5, C V. Mosby Company.)

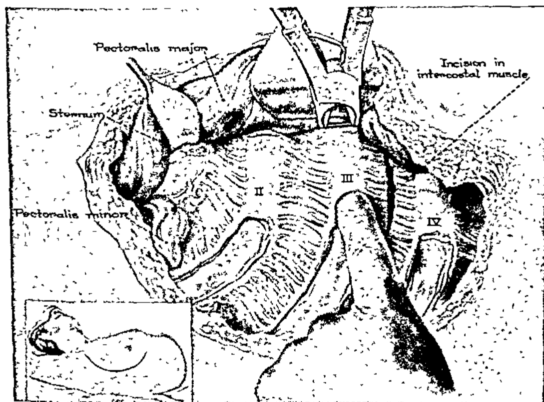


FIGURE 217. Complementary anterior thoracoplasty. The second, third and fourth anterior costal stumps and the first costal cartilage have been resected. The second and third cartilages are divided and hinged at the sternum. Insert shows anterior axillary incision usually used. (Alexander: J. Thoracic Surg., Vol 2, C. V. Mosby Company.)

pectoralis major. The anterior ends of the upper four ribs with their cartilages are exposed by retracting all tissues inward.

The remaining portions of the second, third and fourth ribs are removed from their periosteum by dividing them at their costochondral junctions and dissecting outward while holding the rib ends with forceps. The outer ends may be adherent and require careful dissection to avoid tearing the pleura. Regenerated portions of rib may also require removal. These are often very adherent and irregular in shape. If a regenerated first rib is to be removed, great care must be used not to injure the subclavian vein, which is in close proximity. The second and third costal cartilages are next divided near the sternum to permit the cartilage to fall inward or to be pressed inward as the cartilage is divided.

Instead of severing the cartilages, they may be completely removed subperichondrially. This may permit a somewhat greater lung collapse than the foregoing method. The wound is usually closed without drainage by suturing the muscles with plain catgut and the skin with silk. The use of a pressure pad for two or three months after operation will push in the cartilages and produce maximum permanent collapse.

Osteoplastic Thoracoplasty (Björk) (Figs. 218, 219)

The removal of ribs in the standard thoracoplasty procedure described above converts the rigid chest wall into a nonrigid structure. This results in paradoxical movement with resultant impairment of alveolar ventilation. In addition, the unstable chest wall impairs effective cough with an increase in the incidence of atelectasis. Fluid may also accumulate in the apicolysis space to produce increased compression atelectasis of the lung with decreased ventilation. Tight strappings and sand bags aid in preventing paradoxical motion; however, none of these measures completely abolishes movement of the flail chest wall during respiration and coughing. For the reasons outlined above, many modifications of standard thoracoplasty have been developed in an effort to retain a rigid chest wall in the desired collapsed position. Björk, of Stockholm, has devised an operation which overcomes many of the disadvantages of the standard thoracoplasty.

Technique of Operation. A paravertebral incision is made and continued anteriorly at least 5 cm. below the tip of the scapula as for standard thoracoplasty. The trapezius and rhomboid muscles are then divided as near to the spinous processes as possible.

The thoracic dome is thus exposed, and the scalenus posterior, medius and anterior as well as the serratus anterior fibers to the first and second ribs are divided well above the attachments to the periosteum to avoid impairment to the nutrition of the ribs. The posterior ends of the upper five ribs are resected in increasing lengths from above downward. The ribs are divided at the tip of the transverse processes, which are always left intact. Roughly, a little more than five fingerbreadths of the fifth rib, four fingerbreadths of the fourth rib, three fingerbreadths of the third rib, two fingerbreadths of the second rib and one fingerbreadth of the first rib are resected. The ribs are then bent downward toward the sixth rib to ascertain their optimal length in position and more rib excised if necessary. The posterior end of the first rib is pulled downward and the remaining muscle attachments cut with scissors, care being taken

to protect the subclavian vein. The rib is further dissected anteriorly and the first costal cartilage divided as close to the sternum as possible, taking care to avoid injury to the internal mammary artery. The apex of the lung is then freed by dissecting the extrapleural fascia downward to the level of the aortic arch on the left or the azygos vein on the right.

The upper five ribs are then bent downward and fixed to the sixth rib by means of medium steel wire passed through drill holes in the ribs. The first rib is usually fixed to the fifth transverse process. The mediastinal pleura is sutured to the upper margin of the first rib to complete the closure. In this fashion a stable roof of the chest is obtained. In some instances six or seven ribs may be partially removed and brought down to the highest remaining complete rib in the same fashion. When this type of thoracoplasty is combined with lobectomy, the first rib is usually left in place. After this procedure the apicolysis space is routinely drained.

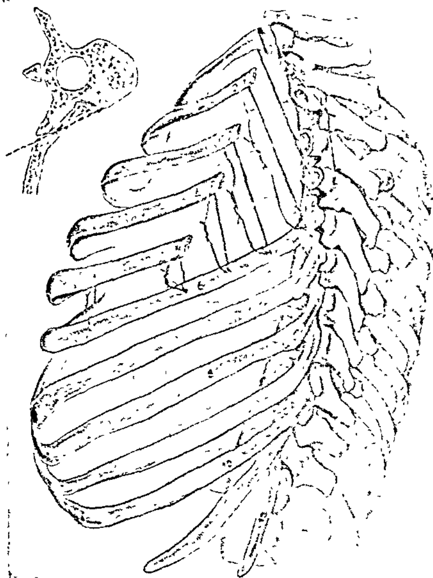


FIGURE 218 Osteoplastic thoracoplasty Posterior segments of the upper 5 ribs have been resected in increasing lengths from above downward Wire sutures have been placed through drill holes in the ribs preparatory to bringing the ribs downward The first rib is anchored to the transverse process of the fifth thoracic vertebra, the other ribs to the sixth rib (V. O. Björk: J Thoracic Surg., Vol. 28)

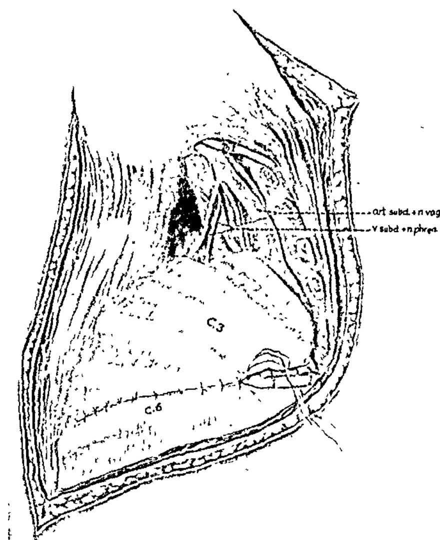


FIGURE 219. Osteoplastic thoracoplasty (*concluded*). The upper 5 ribs have been brought down by bending at the cartilages anteriorly and secured with wire sutures placed in drill holes. Apicolysis is carried down to the level of the aortic arch on the left or to the azygos vein on the right side In this fashion a stable roof of the chest wall is obtained. (V. O. Bjork: *J.* Thoracic Surg., Vol 28)

Plombage

In an effort to overcome some of the disadvantages of routine thoracoplasty as enumerated in the preceding section, many authors have attempted to produce collapse therapy by implanting various materials into the pleural or extrapleural space. The procedures utilizing such materials as paraffin, Ivalon sponge, Lucite balls and others have enjoyed early success and enthusiasm only to be abandoned for the most part when they failed to withstand the test of time The technique of extraperiosteal plombage thoracoplasty as devised by Wilson, Overholt and others has been used with success in certain types of patients. In this procedure the periosteum is stripped from the upper ribs and the underlying lung collapsed by compressing the periosteum and intercostal bundles by Lucite spheres placed inside a polyethylene wrapping, leaving the denuded ribs in place. This procedure is one of the simplest and safest of all major surgical procedures used in treating tuberculosis and may be used on poor-risk patients and those whose organisms are resistant to the antimicrobial drugs With this type of collapse the disadvantage of paradoxical motion and difficulty in raising secretions is minimal. Since the ultimate fate of the Lucite balls and wrapping

is unknown, the plomb along with the previously denuded ribs is usually removed in approximately four to six months in younger good-risk patients if the sputum remains negative. In older patients the plomb is allowed to remain.

If the plomb is removed, the first rib and all transverse processes are left intact so that the resultant deformity and scoliosis are minimal. If, after the first stage of this type of plombage is completed, resection therapy is indicated, this can be combined with removal of the Lucite balls and previously denuded ribs as a second-stage operation with ease.

Technique of Operation (*Wilson*). The standard paravertebral incision is made as in other types of thoracoplasty. The number of ribs and the length of ribs to be stripped of periosteum depend upon the extent and distribution of the lesion as determined by previous x-ray studies. As many as eight ribs may be stripped at one operation. Starting from below upward, the ribs are stripped of their periosteum in routine fashion from their attachments to the transverse process forward, although the external periosteal covering may be left attached to the rib. The ribs are left intact. When the first rib is reached, the periosteum is stripped only from the under surface of the rib and the extent of collapse increased by apicolysis of the fascia The periosteal space is then packed snugly with 1¼-inch Lucite spheres inside a polyethylene wrapping to prevent migration of the spheres and simplify removal at a later time if necessary. More recently polyethylene film alone has been used as packing. A Penrose drain is placed in the subscapular space and the wound closed in layers.

HERNIA OF THE LUNG

Hernias of the lung may be congenital or acquired The congenital type of hernia is commonly found in the superior thoracic aperture or in the interspaces near the sternum. Acquired hernias usually follow trauma to the thorax. Spontaneous hernias may occur as a result of increased intrathoracic pressure, and hernias may develop after disease of the chest wall.

Technique of Repair of Lung Hernia (Fig. 220)

In the repair of lung hernias Mauer and Blades recommend the utilization of the tissues of the chest wall. Endotracheal anesthesia is necessary. An incision is made over the hernia to expose the hernial opening and the adjacent ribs. The adherent lung is freed from the margins of the hernial opening, and the pleura is closed with interrupted sutures of silk. If the intercostal muscles are intact, they are freed and closed with interrupted silk sutures. Flaps of periosteum are dissected from the rib immediately above and below the opening and sutured together over the defect with interrupted sutures of silk. The overlying muscles and skin are closed with silk.

When portions of ribs are lost, the ribs above and below are used to bridge the defect. The rib above may be severed and sutured end-to-end to the defective rib below. Incisions through the ribs are made obliquely so that the approximated ends will lock when sutured to hold them in position. Three drill holes are made in the rib ends, and no. 1 chromic catgut is used for sutures. Periosteal flaps are constructed from the transferred ribs above and below the defect and sutured together with inter-

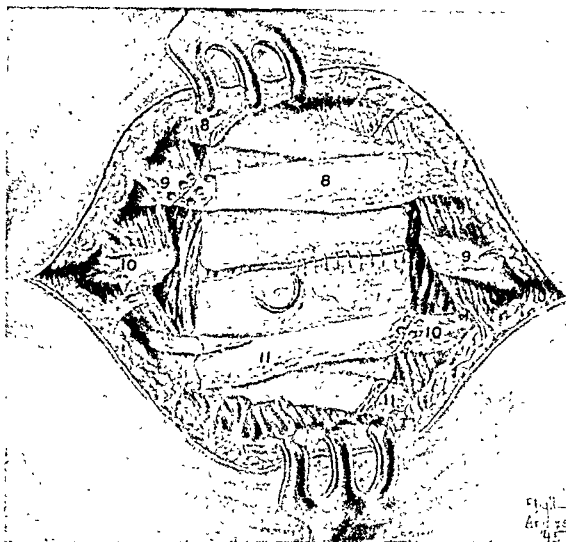


FIGURE 220. Technique of repair of lung hernia. Portions of 2 ribs are missing. The periosteum of the eighth and eleventh ribs has been raised to form flaps to close the defect. These ribs have been divided tangentially and sutured to the rib stumps of the ninth and tenth ribs with chromic catgut placed through holes drilled in the rib ends. The periosteal flaps are sutured together, beneath the ribs. (Mauer and Blades: J Thoracic Surg, Vol 15, C V. Mosby Company.)

rupted silk sutures. The combination of shifted rib ends and sutured periosteal flaps will make a firm closure.

PECTUS EXCAVATUM

Pectus excavatum, or "funnel chest," is a deformity of the sternum and anterior chest characterized by an inward bowing of the body of the sternum, beginning at the lower margin of the manubrium and most pronounced at the lower or xiphoid end. There is an accompanying bowing of the lower costal cartilages inward to form a depression. The deformity usually is present at birth and in many cases is progressive. In many instances, particularly during childhood, there is a paradoxical motion of the sternum on respiration. The deformity may lead to severe postural abnormalities, and cardiorespiratory disturbances of varying degrees may develop. In addition, psychological disturbances may develop because of the cosmetic features. The indications for operation, therefore, are (1) orthopedic, (2) cosmetic, and (3) physiologic. When the deformity is mild and the patients are asymptomatic, operation may not be necessary.

Technique of Operation (Ravitch) (Figs. 221 to 224)

With the patient under general anesthesia, a midline vertical incision is made from the manubrium to the epigastrium. The pectoral muscles are stripped back from the sternum, exposing the costal cartilages to the full extent of their deformity. The lowermost costal cartilages are then stripped of their perichondrium if possible. This may be difficult. These cartilages are then divided at the lateral edge of the deformity and disarticulated from the sternum medially. It is now possible to expose and divide the xiphoid sternal junction, after which the xiphoid pulls away from the body of the sternum. The finger then can be introduced into the mediastinum from below and the sternum freed of attachments as high as the manubrium. The remainder of the deformed cartilages, usually numbering three to five, are then removed subperichondrially, and the intercostal bundles are divided, leaving the body of the sternum attached only to the manubrium above. A transverse cuneiform osteotomy is made at the beginning of the downward curve in the sternum, using a gouge, and the sternum is then bent sharply forward, fracturing the posterior cortex.

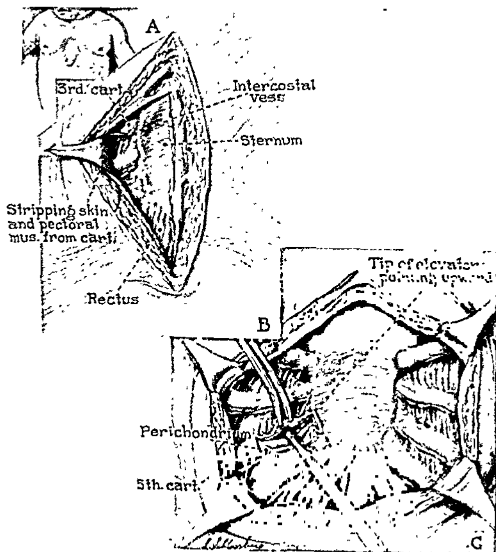


FIGURE 221 Pectus excavatum. A midline incision is made from the manubrium to the epigastrium and a flap of skin, fat, and pectoralis major reflected back on either side (*B*). The perforating vessels are brought into view and are clamped and divided as this is done. Longitudinal incisions are made in the perichondrium of the deformed cartilages with cross incisions at either end. The perichondrium is elevated with fine instruments aided by traction on the cut edge (*C*). (M. M. Ravitch: Surg., Gynec. & Obst., May, 1958. By courtesy of the publishers.)

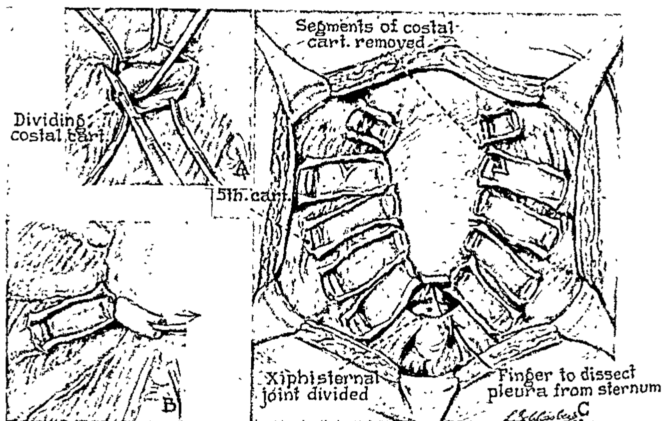


FIGURE 222 Pectus excavatum (*continued*) Each deformed cartilage in turn is removed subperichondrially for the full extent of its deformity. Three to 5 cartilages may be so removed. The xiphoid is divided from the sternum and the finger inserted in the mediastinum (*C*). (M. M. Ravitch. Surg, Gynec & Obst, May, 1958. By courtesy of the publishers.)

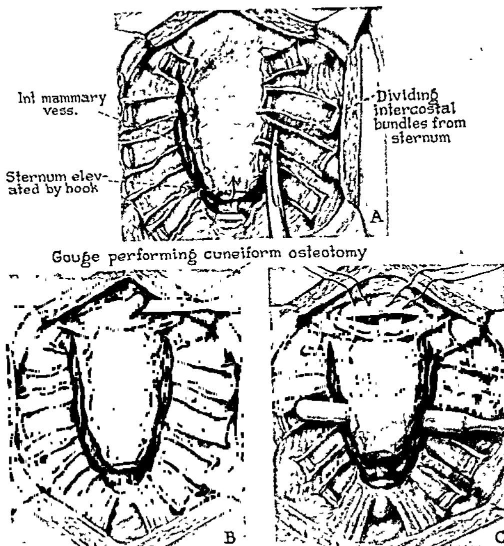


FIGURE 223 Pectus excavatum (*continued*). The sternum being held up by a hook (not shown) after the finger has stripped the pleura back to either side, the intercostal bundles are divided from the sternum. These drawings were made of operation in a 6-months-old baby in whom the correction could be adequately achieved in this way. In most instances the next higher costal cartilage, usually the third, is divided with the scalpel close to the sternum, permitting the subsequent sternal osteotomy to be made in the second interspace, rather than the third. The sternal periosteum is incised (*B*), stripped back and an osteotomy performed with a gouge and deepened if necessary with osteotomes or curets. The sternum is lifted forward and back until the posterior cortical lamella has been fractured and the sternum easily maintained in corrected position. Stabilized by an instrument passed behind it (*C*), it is maintained in corrected position by mattress sutures of heavy braided silk placed across the osteotomy. (M. M. Ravitch. Surg, Gynec. & Obst., May, 1958. By courtesy of the publishers)

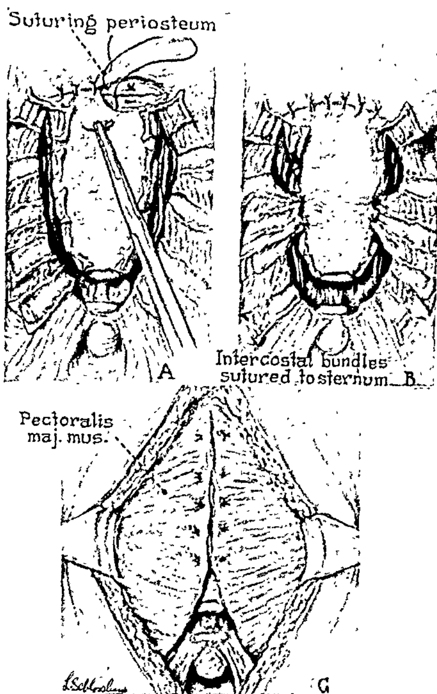


FIGURE 224. Pectus excavatum (*concluded*) Sutures of 0 or 00 silk in the periosteum further reinforce the maintenance of the sternum in good position (*A*). In older patients in whom an additional costal cartilage (usually the third) has been merely divided, this is now resutured with a heavy silk suture, in its corrected position, the medial end more prominent than the lateral end Any excess of the intercostal bundles is trimmed away, and one or two sutures of 0000 silk lightly tack the intercostal bundles to the sternum on either side (*B*). If this results in any visible tension on the sternum, with respiration, the sutures are cut away and no attempt is made to attach the intercostal bundles. The xiphoid is left separated from the sternum The pectoralis major muscles are tacked back to the sternal midline (*C*) The skin is closed with subcutaneous and cutaneous sutures of 0000 silk and sprayed with an aerosol plastic No external fixation of any kind is done (M M Ravitch· Surg, Gynec. & Obst, May, 1958 By courtesy of the publishers.)

Mattress sutures of braided silk are then placed through the bone at the site of osteotomy to secure the two portions of the sternum in an overcorrected position. In addition, sutures are placed through the periosteum for reinforcement. The previously divided intercostal bundles may then be sutured to the edges of the sternum, and the edges of the pectoral muscles are reunited to the sternal periosteum. No attempt is

made to replace the xiphoid or to reattach the rectus muscles. The subcutaneous tissue and skin are then closed in layers with interrupted sutures. The use of skeletal traction attached to an apparatus on the chest wall is not necessary to maintain the corrected position in most instances.

PLEURAL SPACE

ACUTE EMPYEMA

Dangers and Safeguards

Regardless of the type of infection, open drainage should not be instituted until the purulent exudate has thickened, indicating localization and some degree of fixation of the mediastinal structures. Open drainage is dangerous when the exudate is serous or seropurulent. The optimum time for drainage can be easily determined by placing the aspirated exudate in a test tube and allowing it to stand overnight in an ice box. If the exudate shows little or no serum above the purulent content of the tube, the empyema is ready for drainage. If the empyema is not ready for drainage, repeated aspirations are indicated to reduce pressure and relieve respiratory distress until the exudate has become frankly purulent.

When aspirating or incising the thoracic cage, the anatomy of the diaphragm must be kept in mind to avoid injury to this structure. A wound of the diaphragm might lead to a fatal peritonitis. An acute empyema is most efficiently drained in the posterior axillary line at the ninth interspace. A drainage in this location offers the advantage of gravity with the patient supine or in a semisitting posture. To avoid incision or resection of a rib in an improper location, an exploratory aspiration should be made before operation. Intercostal incisions should be made just above the rib to avoid injury to the intercostal vessels and nerve, which lie immediately below the rib margin. Severe hemorrhage may result from a severed intercostal artery. When a rib is resected, the blood vessels and nerves may be avoided by careful stripping of the periosteum.

In cases of encapsulated or interlobar empyema, the rib resection should be made where the approach to the purulent collection is most direct. In some of such cases it is advisable to use the two-stage method of drainage, as in lung abscess, to avoid pleural contamination.

Technique of Rib Resection (Fig. 225)

Local anesthesia is desirable in most cases of rib resection. An incision 6 to 8 cm. long is made directly over the rib selected after needle aspiration. When drainage is being done for empyema developing as a complication of lung surgery when thoracoplasty may be necessary at a later date, placement of the drainage site anteriorly is preferable. The incision is carried through all tissues to the rib. The periosteum is incised and carefully stripped from the rib with a periosteal elevator. About 5 cm. of the rib are then cut away with the rib shears. A small opening is made through the posterior rib periosteum and pleura into the pleural cavity. Pus is evacuated slowly, preferably with a sucker. A rubber drainage tube 1 to 2 cm. in diameter is placed in the opening to fit snugly. The end penetrating the cavity should extend just far enough into the chest to obtain adequate drainage. A long tube is undesirable, since

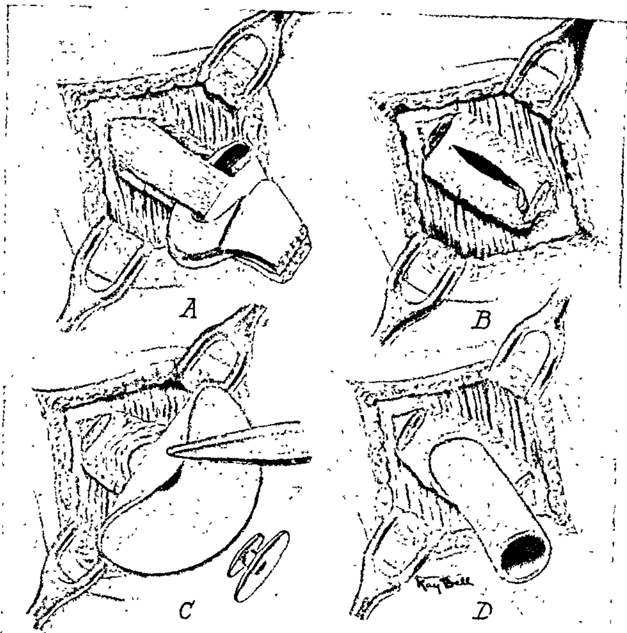


FIGURE 225 Technique of rib resection for acute empyema. *A*, Tissues over rib divided parallel to rib. Periosteum of rib reflected and rib shears in place. *B*, Section of rib removed and opening made into pleural cavity. *C*, Wilson button inserted for drainage. *D*, Large tube inserted for drainage.

it produces needless irritation and forms an infected channel when the lung expands. The wound is closed snugly about the tube, and the tube is fixed to the skin with a loose, nonabsorbable suture. A Wilson button may be used in children and in adults when the chest wall is thin.

Drainage should be continued until the cavity is obliterated. The tube may usually be safely removed when the cavity contains only 10 to 15 cc. by measure. Frequent x-ray examinations are a valuable guide in estimating the size of the cavity. Injection of Lipiodol will aid in visualizing the cavity.

Graham recommends daily irrigation of the empyema cavity with Dakin's solution. A 5 per cent sodium chloride solution has been used with satisfaction by the authors. When pleural irrigations are started, the possibility that a bronchial fistula may exist should be recognized to prevent aspiration of irritating solutions.

An empyema is not considered healed until the cavity is completely obliterated.

Chronic empyema may develop even after a period of several weeks or months of apparent good health.

The mortality rate varies with age, race, season and year. When pneumonia is severe with a high mortality, empyemas are likely to have a high death rate. The death rate usually varies between 5 and 30 per cent. In recent years, the use of antimicrobial drugs has reduced the incidence of empyema greatly.

Technique of Decortication for Acute Empyema (Fig. 226)

Burford, Parker and Samson recommend early decortication of the lung in the treatment of post-traumatic empyema. Sanger concurs in this recommendation and has extended the treatment to include cases of acute postpneumonic empyema.

The less severe types of post-traumatic empyema are treated by rib resection and drainage, and the more severe types, which are most likely to develop chronic empyema, are chosen for decortication. If a patient is too ill to tolerate decortication, preliminary drainage is advised.

Decortication is indicated within four weeks after injury if the lung does not expand after aspiration or drainage of the pleural cavity.

An endotracheal anesthetic is used in all cases. A posterolateral incision is made over the fifth, sixth or seventh rib. Adequate exposure is usually obtained by resecting a rib. As soon as the pleural cavity is entered the lung should be freed from the parietal pleura All pus, old blood clots, and fibrin should be removed. If a bronchopleural fistula does not exist, the pleural cavity may be thoroughly washed with physiologic sodium chloride solution.

The fibrinous layer over the lung is incised down to lung tissue, and from this incision decortication is begun. The dissection can usually be done best with forceps

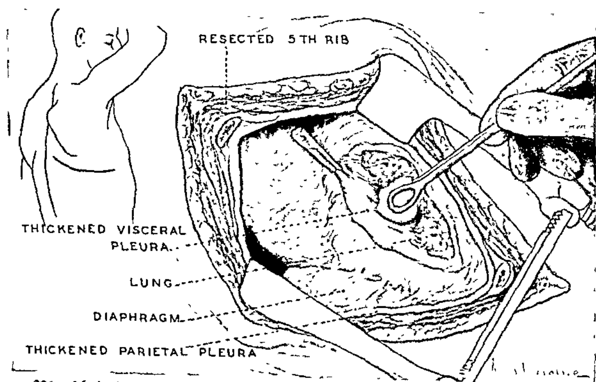


FIGURE 226 Method of removing densely adherent membrane from the compressed lung by blunt sponge dissection (Redrawn from Sanger: Surg., Gynec and Obst.)

and a small sponge dissector. There may be troublesome oozing from the surface of the lung, and the lung can be easily torn along fissures. Tears in the lung should be closed with silk sutures. The fibrinous layer over the parietal pleura and the pleura covering the diaphragm need not be removed. The diaphragm should be mobilized by freeing the margins.

Bronchial fistulas are treated by freshening the margins with sharp dissection and closure with fine silk sutures.

If a lung abscess exists, the necrotic lining should be removed and the cavity closed with silk. Foreign bodies should be excised and the defect in the lung closed.

At the completion of the operation the lung should be expanded and the primary thoracic wound closed with silk without drainage. Two or three intercostal tube drains should be inserted and connected with waterseal bottles. The pleural cavity is irrigated and aspirated as dry as possible. Penicillin may be introduced into the cavity. Antibiotics are advised.

CHRONIC EMPYEMA

General Considerations

Chronic empyema may result from neglect in the proper management of acute empyema or from inadequate drainage of acute empyema, or from chronic pleural effusion as in pulmonary tuberculosis. In general, patients with chronic empyema are not good surgical risks. As a result of prolonged suppuration they are frequently anemic, undernourished and may have cardiac and renal damage. Therefore, supportive measures such as blood transfusions for the correction of anemia, as well as increased nutritional and vitamin intake, are indicated in an effort to improve the patient's general condition.

Smaller empyemas without appreciable pulmonary compression may be managed by aspiration, lavage and the injection of proper antibiotics. Rib resection and drainage may also be all that is necessary for the usual posterior and lateral pockets if small. On the other hand, a massive empyema with chronic subtotal collapse of the lung or a smaller empyema unobliterated by aspiration or drainage is best handled by decortication. If the general condition of the patient is good, primary decortication may be undertaken. However, wasting and debilitation may be so severe that external drainage may be necessary before decortication. In instances in which the lung beneath the empyema cavity is too diseased to make it safe to bring about its expansion or to make it worth while from a functional standpoint, closure of a chronic empyema cavity by thoracoplasty is indicated. Thoracoplasty may also be necessary when decortication has failed to re-expand the lung or in instances of empyema following total pneumonectomy.

Technique of Decortication for Chronic Empyema

General endotracheal anesthesia is used. The position of the patient on the table and the incision to be used are determined somewhat by the location and extent of the empyema cavity. For most cases a classic posterolateral thoracotomy with subperiosteal resection of the sixth or seventh rib is satisfactory. In chronic empyema, especially of the tuberculous type, an attempt is made to remove the envelope completely

without opening it or spilling the contents. When the rib is removed, the parietal portion of the rind is peeled away from the chest wall. In many cases the parietal pleura is removed along with the rind. The dissection is carried along the chest wall up into the lung proper. If the parietal pleura has been removed along with the rind, it will be necessary to change from extrapleural to intrapleural dissection as the peel is removed from the lung. The visceral portion of the empyema cavity is then removed from the lung. If one has been successful in avoiding entry into the empyema cavity, a bag filled with pus may be totally removed from the thoracic cavity without leakage.

It may be necessary to free the interlobar fissures, and in some instances additional peel must be removed from the pleural surfaces. A few pleural leaks are inevitable, and blood loss is often considerable. Pleural leaks may be closed with suture, and hemostasis is obtained. The electrocautery is often a great help in securing hemostasis. Anterior and posterior tubes are placed for waterseal drainage, and the chest wall is closed in layers.

Pleuropneumonectomy

In instances of chronic empyema in which the underlying lung is so severely damaged that re-expansion is not possible or is contraindicated, the entire empyema cavity and lung may be removed. In this procedure the entire parietal rind along with the parietal pleura is removed down to the hilum of the lung, after which the hilar structures are individually dissected and ligated and a pneumonectomy performed. The pleural cavity is then closed without drainage as with other forms of pneumonectomy.

Estlander's Operation

After outlining the cavity by x-ray study and exploration through existing sinuses, an incision is made through all tissues down to the overlying ribs long enough to span the entire cavity. Two or three ribs are resected through this incision. One or more similar incisions are made above or below, through which a sufficient number of ribs are removed to permit collapse of the soft tissues over the cavity. Instead of multiple incisions, U-, T-, or H-shaped incisions may be made. Because of the rigidity of the parietal pleura, collapse is often not sufficient to obliterate the cavity. The operation of Schede, or some of its modifications, better serves the purpose except in small superficial cavities.

Schede's Intrapleural Thoracoplasty

General Considerations. In certain instances of chronic empyema in which decortication, pleural pneumonectomy or simpler thoracoplasty has failed to obliterate the cavity, it is necessary to resect the overlying ribs as well as the thickened parietal peel and the intercostal bundles. By excising the outer wall of the cavity in this fashion, the soft parts of the thorax in the corresponding area are allowed to fall against the lung with ultimate healing of the wound by granulation tissue and epithelialization from adjacent structures. It may be advisable to complete the operation in two or more stages, depending upon the general condition of the patient and the extent of tissue to be excised.

Technique of Operation. An incision is made, which may be modified to suit the

location and size of the empyema cavity. The flap outlined should be somewhat larger than the area of ribs to be removed. All tissues are incised down to the ribs. The skin and soft structures within the outlined flap are dissected from the ribs and intercostal tissues to be resected. The scapula with its muscular attachments is separated from the ribs and retracted with the flap when necessary. An incision is made through the periosteum over each rib, and the rib is separated with a periosteal elevator and removed with rib shears. Each exposed end of severed rib should be removed with rongeurs well back beneath the periosteum to prevent later infection and necrosis of the denuded section. The limits of rib resection should extend 2 cm. beyond the margins of the underlying cavity so that the soft parts will collapse into and readily obliterate the cavity. The intercostal vessels are next ligated at each end near the severed ribs by passing sutures of catgut on a curved needle about the tissues just below periosteum of each resected rib. The wall of tissue, including intercostal muscles, periosteum and parietal pleura, is then cut away in a single sheet by an incision following the line of severed rib ends. All bleeding points are carefully ligated with catgut. The retracted flap of skin, fascia and muscle is then replaced and fixed with chromic catgut sutures in the muscle and fascia, and silk or other nonabsorbable suture material in the skin. An opening is left at the most dependent portion of the incision for drainage. A marine sponge pressure dressing is advised.

Pedicled muscle flaps cut from the latissimus dorsi or other muscles are often of distinct value in obliterating a large cavity, particularly when there are pockets or diverticula extending laterally or upward from the main cavity. The muscle flaps may be sutured in these pockets with catgut. Excision of a portion of the scapula may permit the use of scapular muscles to aid in closing the defect. The chest wall flap will not collapse into the cavity and should be held in contact with the visceral pleura by a pressure dressing of folded gauze or a sterile sea sponge. The portion of the wound not covered by the chest wall flap is then packed open with long strips of gauze. If there follows a purulent discharge from the wound, irrigation with Dakin's solution is indicated.

BRONCHIAL FISTULA

Technique of Closure (Figs. 227, 228)

Bronchial fistula may occur as a complication of empyema, of lobectomy or pneumonectomy or of the drainage of a lung abscess. In general, these openings in the bronchus may be attacked directly with an attempt to close the opening and obliterate the remaining cavity. If the bronchopleural fistula is small, it may heal spontaneously after full re-expansion of the lung and healing of infection. Cauterization of small fistulas with the electric cautery or chemical agents may rarely effect a closure. When the fistula accompanies a chronic empyema, direct closure of the fistula with interrupted sutures followed by decortication and re-expansion of the lung is usually successful. In other instances the use of pedicle flaps of the chest wall muscles stuffed tightly into the fistula and held in place by interrupted sutures around the periphery may be effective When this method is used, a concomitant thoracoplasty of the Schede type is usually necessary.

Shenstone advises the use of an intercostal muscle as an implant into the fistulous



FIGURE 227. Technique of closure of bronchial fistula, using muscle flaps.

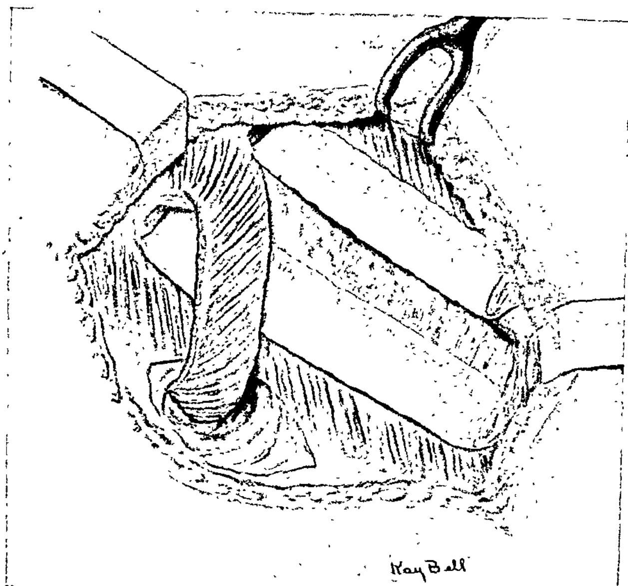


FIGURE 228. Closure of a bronchial fistula by the implantation of an intercostal muscle into the depth of the fistulous tract (After Shenstone: Ann. Surg., 1936)

tract (Fig. 228). The scar of the original wound is excised and the wound margins widely retracted to expose normal intercostal muscles. Two ribs are resected for a sufficient distance to form a pedicled graft of an intercostal muscle. The blood supply to this muscle should not be damaged. The muscle is cut across anteriorly and stripped from the underlying pleura. The free end of the pedicled graft is then implanted into the depth of the fistulous channel and held in place by interrupted catgut sutures. The thoracic wound is closed with tube drainage.

LUNG

LUNG ABSCESS

General Considerations

The incidence and treatment of suppurative pulmonary disease have changed greatly with the use of antimicrobial drugs. Indeed, the presence of a pulmonary abscess should make one highly suspicious of underlying bronchogenic carcinoma with secondary suppuration, and one of the prime concerns in the management of these

cases is thorough diagnostic study in an effort to determine the presence of an underlying carcinoma. Many abscesses on a regimen of specific antimicrobial therapy, postural drainage and general supportive measures will heal without operative intervention. Depending upon the circumstances, lung abscesses may be managed either by resection therapy or by open drainage procedures.

The indications for open drainage are (1) the occasional fulminating acute abscess that fails to respond to conservative treatment and which must be drained as a lifesaving measure; (2) the general condition of the patient, due to illness or intercurrent disease, such that the risk of extirpative surgery is too great; and (3) the occasional, solitary, uncomplicated acute abscess located peripherally which may be treated with drainage with good results. In all other instances, indeed in the vast majority of those cases requiring surgical intervention, resection therapy is indicated.

Technique of Operation

1. *Intercostal Drainage.* In a small percentage of selected cases a parietal lung abscess may be drained between the ribs. An incision is made parallel to the overlying muscle fibers, which are separated and retracted to expose the ribs. The incision is then cautiously extended through the intercostal muscles to the parietal pleura. The intercostal muscles are retracted and evidence of movement of the lung noted. If the pleura is thickened and the normal gliding respiratory movement of the lung is absent, the abscess may be opened at once. If adhesions have not formed between the pleural surfaces, the operation is interrupted at this point and the wound packed open with gauze to promote adhesions. To increase the area of pleural adhesions, it is usually wise to abandon the intercostal technique and resect a rib. After seven to ten days the wound may be opened to complete the operation. At this time pleural adhesions are usually sufficient to protect the free pleural cavity from contamination. To locate the abscess, it is wise to introduce an aspirating needle. When pus is found, the needle may be followed with knife, hemostat or cautery into the abscess cavity. A biopsy of the abscess wall should be taken to rule out unsuspected carcinoma or tuberculosis. An opening into the abscess cavity should be made of sufficient size to admit a finger freely. Soft rubber tube or multiple cigarette drains may be used.

2. *Costectomy with Drainage.* In a majority of the cases rib resection will be the operation of choice to give ample exposure and good drainage. The location of the abscess as shown by the x-ray film determines the line of skin incision. The incision should be made as directly over the abscess as possible to avoid exposing normal pleura. A segment of rib 5 to 8 cm. long, overlying the abscess, is freed of its periosteum by a periosteal elevator and removed with bone forceps or specially designed rib shears. The pleura is gently exposed through an incision in the posterior periosteal rib covering. If the pleurae are adherent, the abscess may be entered at once and drained as noted above for intercostal drainage.

A *two-stage operation* with rib resection is often much safer than a completed primary drainage. If this plan is to be followed, the technique described by Hedblom is satisfactory (Fig. 229). The periosteum is stripped from two or three ribs for a distance of 8 to 10 cm. One of these ribs, usually the middle if three are exposed, is resected. The wound is then packed with gauze snugly placed against the intercostal muscle and beneath the exposed ribs and the wound closed. At the end of eight to ten

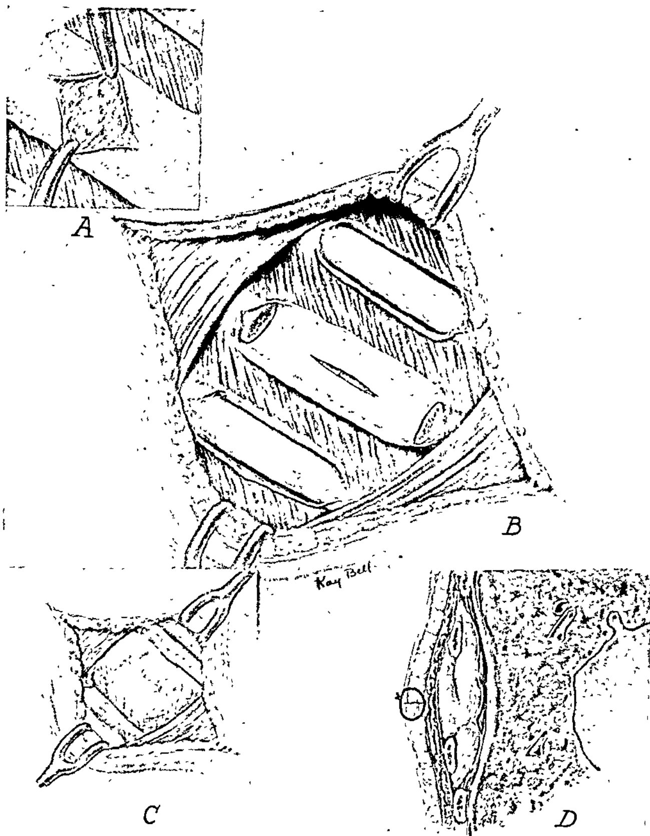


FIGURE 229 Technique of drainage of lung abscess in 2 stages *A*, Rib resected and posterior rib periosteum incised, exposing normal mottled lung *B*, One rib resected and periosteum raised from 2 adjacent ribs later to be resected *C*, Gauze packing beneath denuded ribs to form adhesions between parietal and visceral pleurae *D*, Cross section showing gauze pack in place with wound closed. Note pressure on pleurae to promote adhesions (Redrawn from Hedblom Lewis' Practice of Surgery, Vol V, W F. Prior Co)

days the wound is reopened, and the abscess is located with a needle before the denuded ribs are resected. When the abscess is located, the exposed ribs are resected and the abscess opened. The opening into the abscess should be large enough to admit the finger for exploration and biopsy. A large abscess may be inspected and traversing blood vessels clamped and tied. Blood vessels exposed in the abscess cavity may be easily torn and may cause serious hemorrhage. Ample drainage with a soft rubber tube or cigarette drain is necessary for rapid healing. The position of a rubber tube should be changed frequently to prevent erosion into a bronchus or blood vessel. The wound in the skin and soft tissues of the chest wall is usually left open to afford good drainage.

In selected cases of old chronic abscesses at the periphery of the lung, an "unroofing" operation, similar to that used for chronic empyema cavities, may be the procedure of choice.

Resection. When a lung abscess fails to heal on conservative management, resection therapy is indicated in the vast majority of cases. With the use of heavy antimicrobial coverage the operative mortality and morbidity rate in these cases has been greatly reduced during the last decade. Conservation of nondiseased pulmonary tissue is desirable so that accurate localization of the abscess before operation is indicated. The involved portion of lung is then removed by segmental resection, lobectomy, wedge resection or, in some instances, pneumonectomy as indicated. These techniques are described elsewhere. In some instances it is possible to peel a chronic lung abscess out of the lung parenchyma without sacrificing any surrounding lung tissue, as described by Holman.

LUNG BIOPSY

General Considerations

Occasionally in patients showing disseminated pulmonary disease on roentgenologic examination, a specific diagnosis cannot be made by means of the usual diagnostic procedures. In such patients a lung biopsy as described by Klassen may be necessary in order to establish a diagnosis. This procedure can be done with a minimum of risk to the patient. In most instances the procedure can be done under local anesthesia, although positive pressure must be administered by the anesthesiologist by means of a tight-fitting face mask to prevent collapse of the lung when the pleural cavity is opened. General anesthesia may be used if preferred.

Technique of Operation (Fig. 230)

With the patient in the recumbent position, the chest is prepared and draped. In most instances an anterior incision over the third or fourth intercostal space on the right is preferable. Through this approach a margin of all three lobes can be reached for biopsy if indicated. In women the incision is usually made in the submammary position with upward retraction of the breast. An incision 8 to 10 cm. *in length* usually suffices. After the fibers of the pectoralis major and minor muscles have been separated the intercostal space is exposed and the intercostal muscles divided midway between the margins of the ribs. The blades of a medium-size Richardson retractor are inserted

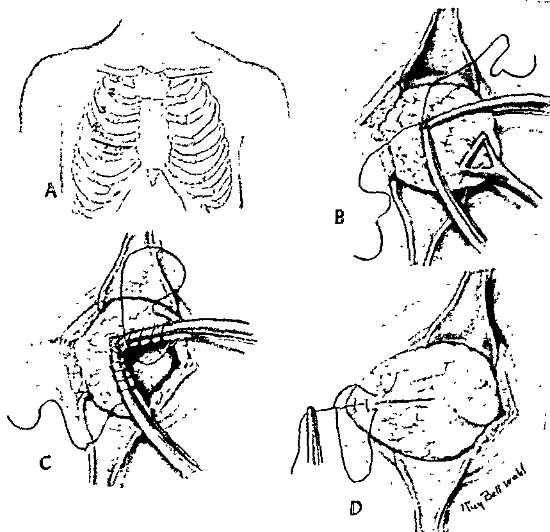


FIGURE 230 Lung biopsy. *A*, Position of incision over fourth intercostal space anteriorly. *B*, Edge of lung grasped with Duval forceps and 2 clamps applied. A mattress suture of catgut is placed at the apex of the wedge *C*, Wedge-shaped section of lung removed between clamps and over-and-over suture using previously placed mattress suture used to close wound edge. *D*, Same suture used to obtain tighter closure as a running Cushing stitch to approximate the visceral pleura.

parallel with the ribs and then rotated 90 degrees to produce spreading of the ribs. As the intrabronchial pressure is increased by the anesthesiologist applying slight positive pressure, the margins of the lobes will herniate into the incision. The edge of the lobes selected for biopsy is grasped with a small Duval lung forceps and brought into the wound. Two clamps are then applied to the edges of the specimen to be removed, with their tips approximating and a mattress suture placed beyond the tips. The wedge of lung tissue to be taken is then removed by cutting along the inner margins of the two clamps.

The two ends of the previously placed mattress sutures are then placed as running over-and-over sutures over the clamps. The clamps are removed, the sutures pulled tight, and the two ends tied. The ends of the sutures can then be placed as a continuous Cushing stitch to approximate the visceral pleura on each side. In this fashion a hemostatic air-tight closure is obtained. A number 14 French catheter is placed in the pleural space and the wound edges closed in layers. Suction as with a bulb syringe can be applied to the catheter and positive intrabronchial pressure maintained by the

anesthesiologist. The catheter is then removed after the placement of the final sutures. Antibiotics may be injected into the pleural space if indicated.

WEDGE RESECTION

Wedge resection is often used for the removal of small benign tumors and certain small inflammatory lesions. This may be done by using a clamp and suture technique described below, or in certain instances an open method may be preferable in which open bronchi and vessels are clamped as they are encountered. Since there is considerable distortion of the remaining lung tissue adjacent to the area removed, segmental resection is usually preferred in larger lesions.

Technique of Operation (Fig. 231)

After routine thoracotomy exposure, long clamps are applied to the margin of the lung well outside the tissue to be excised, the points approximating each other. It often is advisable to place a mattress suture beyond the point of the clamps to prevent the tissue from slipping out of the points of the clamps when the specimen is removed. A continuous basting type of suture is then placed behind the clamps, using catgut suture, or, if one prefers, an over-and-over type of suture may be used. The crushed area is then oversewn with a continuous Lembert suture or an over-and-over suture as preferred. In most instances waterseal drainage is indicated because of the danger of air leaks. The incision is then closed in layers.

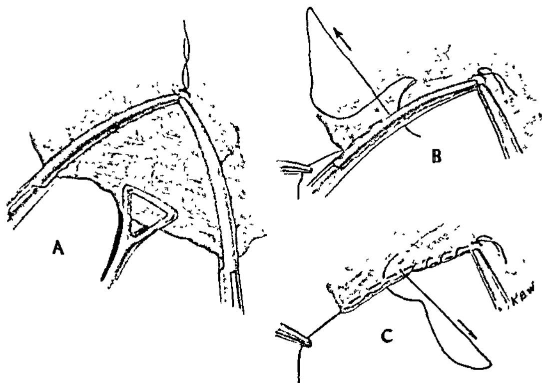


FIGURE 231. *A*, Wedge resection of lesion located in peripheral portion of lung. Clamps applied well beyond margin of lesion. *B*, Placement of suture at apex of wedge to prevent tissue from slipping out of ends of clamps and beginning of suture under clamp. *C*, Lung closed along line of incision with double continuous catgut sutures

SEGMENTAL RESECTION

General Considerations

Overholt and Langer have described the technique for pulmonary segmental resection based on the fact that the bronchopulmonary segment is a surgical unit and may be removed with few technical difficulties. This technique has large application in cases of pulmonary tuberculosis and bronchiectasis in which it is important to conserve as much undiseased lung tissue as possible. Each pulmonary segment is held within the lobe by the bronchus, pulmonary artery and vein, and the visceral pleura. All these structures can be identified and divided before beginning the dissection of the intersegmental plane. The bronchi do not traverse the intersegmental plane, and for practical purposes the plane is avascular. By segmental resection the patient is cured of his disease with the preservation of as much functional lung tissue as possible.

A thorough knowledge of segmental anatomy as well as the common variations is essential before attempting segmental resection.

Technique of Operation (Overholt and Langer) (Figs. 232, 233)

After the opening of the thoracic cavity by routine thoracotomy, the lung is explored thoroughly so that the extent of disease can be determined and the area of

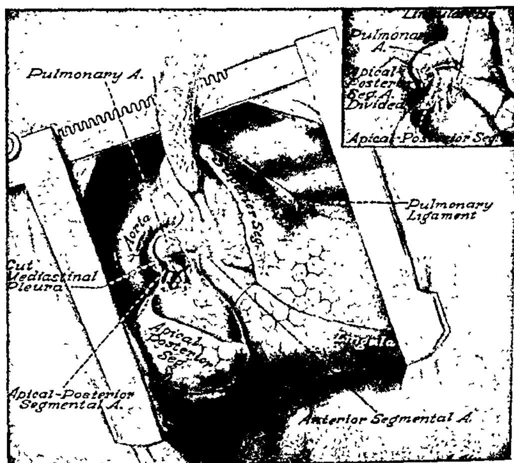


FIGURE 232. Segmental resection of apical posterior segment of left upper lobe The pleura over the first portion of the pulmonary artery has been removed, exposing the apical posterior branches of the pulmonary artery, which have been doubly ligated The insert shows the appearance after the division of the artery and dissection of the apical posterior segmental bronchus (R. H. Overholt and L. Langer· The Technic of Pulmonary Resection)

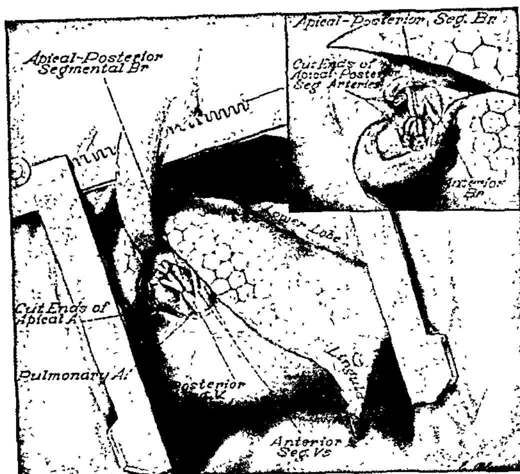


FIGURE 233. Segmental resection of apical posterior segment of left upper lobe (*concluded*). The lung has been retracted posteriorly and the superior pulmonary vein and branches exposed The apical posterior segmental veins have been ligated. In the insert the apical posterior segmental bronchus has been isolated and the lung inflated to delineate the line between the segments. When the bronchus has

tissue for removal selected. In general, the segmental artery, vein, bronchus and the visceral pleura are handled in that order. As an aid in finding the segmental artery, the major fissure should be developed in all segments except the apical posterior (left) and the apical and anterior on the right. After identification, ligation and division of the segmental artery, the segmental bronchus is next identified and divided. The segmental vein, which traverses the intersegmental plane, is next identified. Care must be taken not to compromise the venous drainage of the adjacent segments. When identity is certain, the vein is ligated and divided. The line of demarcation between segments is determined by inflation of the lung, and the visceral pleura is incised completely around the segment at this line. Traction is made on the bronchus, artery and vein. Blunt dissection is used as much as possible. Bronchi will strip out between thumb and finger, and fibrous bands are cut with scissors. Intersegmental vessels may require individual ligation. No attempt is made to close the edges of the remaining segments.

The pleural cavity is washed with warm physiologic sodium chloride solution. Drainage of the pleural cavity by waterseal tubes placed through intercostal stab wounds both anterior and posterior is usually indicated. Controlled suction not to exceed 12 cm. of water may be used. Since there are numerous air leaks present in

the raw surface left behind, extreme care must be taken to prevent atelectasis of the remaining segments. The chest wall is then closed in layers.

Oxygen is usually advised after operation for twenty-four to forty-eight hours. Mucus and pus should be removed from the bronchial tree with vigorous suction before the patient leaves the operating table and as frequently as necessary thereafter. Deep breathing and coughing are encouraged. If these measures are not effective, aspiration of the tracheobronchial tree through the bronchoscope may be necessary. The posterior drainage tube can usually be removed within twenty-four to forty-eight hours when the exudate disappears. The anterior tube is removed when there is no longer any air leak from the denuded segmental surface. Administration of appropriate antibiotics is usually indicated.

PULMONARY LOBECTOMY

General Considerations

The most common *indication* for lobectomy is bronchiectasis. Other indications are benign and certain types of malignant tumors, lung abscess, lung cysts and tuberculosis.

Bronchiectasis is most commonly found in the lower lobes and frequently involves the middle and upper lobes. Churchill and Belsey suggested the term "segmental pneumonectomy" to describe better the usual operative procedure. These authors found that the lingula on the left required resection in 80 per cent of their cases, and Blades reports the right middle lobe involved in 59 per cent. Total pneumonectomy may be indicated in unilateral universal bronchiectasis.

Lobectomy, or segmental resection, is justifiable for bronchiectasis because there is no other curative treatment. Postural drainage, repeated aspirations, collapse therapy and thoracoplasty have given poor results.

Dangers and Safeguards

Accurate delineation of the extent of the disease by x-ray examination is necessary before operation for bronchiectasis is attempted. It is important to visualize all bronchial branches to their finer ramifications. The extent of the procedure must be determined before the operation, since it cannot be determined during the operation. Failure will result if an incomplete resection of the diseased lung is done.

Patients past middle age with bronchiectasis are not considered good risks for lobectomy. Children tolerate the operation well if they have no serious complications such as cardiovascular or renal disease, acute infection or much reduced vital capacity. Operation is contraindicated in patients having a persistent fever or a history of recent pneumonitis.

As *preoperative preparation*, nasal sinus infection should be eradicated. Thorough emptying of the bronchial cavities by postural drainage and repeated aspirations through the bronchoscope are important in many cases. The use of antibiotics and general supportive measures to improve the general state of health is indicated. The bronchial secretions should be reduced as much as possible before operation to minimize the danger of lung infection. Preliminary artificial pneumothorax has been used

to reduce secretions by compressing the dilated bronchi and gradually to accommodate the patient to altered intrapleural pressures. Blades considers pneumothorax of doubtful value.

The danger of *hemorrhage* and *shock* is of great importance. Proper selection of cases, thorough preoperative preparation, and careful technique will reduce these dangers to a minimum. Adequate whole blood and fluid replacement is essential.

During recovery from the anesthetic and preoperative sedation, the patient should be placed on the side operated upon, with the head lowered to prevent aspiration of secretions. Oxygen administered by nasal catheter, mask or tent is usually indicated. Later, frequent changes of position in bed are recommended. Drainage tubes should be carefully watched and frequently cleansed.

Some of the *postoperative complications* which may occur are hemorrhage from the hilar stump, empyema, tension pneumothorax, bronchopleural fistula, pneumonia, atelectasis and general infection.

The results of lobectomy for bronchiectasis are good if the disease is completely removed. The mortality rate should be less than 5 per cent.

Technique of Lobectomy

For lobectomy a posterolateral incision is made extending forward from the angle of the rib to the midaxillary line or farther if many adhesions make exposure difficult. The muscles are cut up to the margins of the erector spinae muscle, which is retracted medially. Removal of a rib, usually the fifth for upper lobectomy or the sixth or seventh for lower lobectomy, affords the best exposure. The ribs are widely separated with a self-retaining retractor.

After opening the chest, adhesions between the lung, diaphragm, chest wall and mediastinum are separated by blunt and sharp dissection. Use of the electrocautery is helpful to minimize blood loss. The pulmonary ligament is separated between clamps and ligated. The interlobar fissure between the upper and lower lobes is identified, and the two lobes are separated. If the fissure is poorly defined, it may sometimes be necessary to divide lung tissue between clamps to isolate the pedicle at the root of the lobe. Tearing of lung tissue is to be avoided.

Blades and Kent first directed attention to the individual ligation technique for the vessels at the hilum. After opening the pleura, the pulmonary artery is first identified. When the main artery is ligated with silk or chromic catgut as near the mediastinum as possible, there remains a stump of sufficient length for a second ligature after the vessel has been clamped and severed.

Enlarged lymph nodes are dissected away to improve exposure of the vein and bronchus. Sometimes difficulty is experienced in separating the vein from the bronchus. The vein is ligated and severed. Occasionally there may be multiple veins or multiple tributaries of a short main trunk requiring mass ligation.

The bronchus should be well exposed. On the left, the lower lobe bronchus is usually of sufficient length for ligation and suture. Separate section of the dorsal division bronchus is rarely necessary. Before the bronchus is divided, the surrounding operative field should be protected with moist packs to prevent soiling. The bronchus is clamped and the proximal end divided and closed with interrupted silk sutures.

The chest wall, muscles and skin are closed in layers. Two intercostal catheters

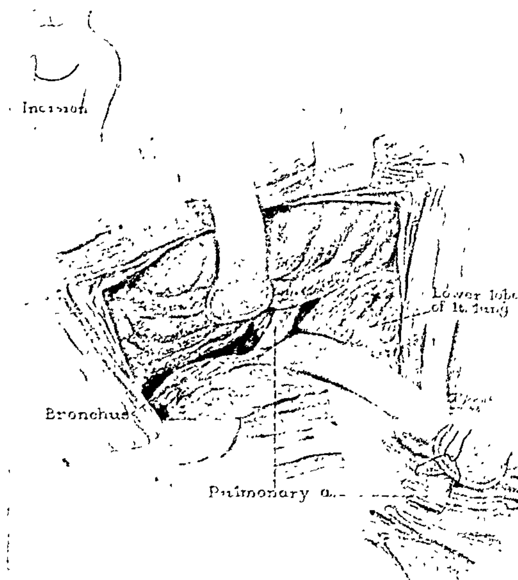


FIGURE 234. Technique of left lower lobectomy and lingulectomy. Upper inset shows location of incision The interlobular fissure has been developed, exposing the pulmonary artery to the lower lobe. The arterial branch to the superior segment of the lower lobe coursing posteriorly and the branch to the lingula coursing anteriorly often arise from the pulmonary artery at the same level and must be ligated and divided separately. (Clagett and Deterling: J. Thoracic Surg., Vol 15)

are inserted through stab wounds, one in the anterior axillary line and the other in the posterior axillary line, and connected to a suction apparatus as soon as the patient is returned to his bed.

On the right the pulmonary vein may be short and divided into two to four divisions near the mediastinum. Because of the fragility of the walls of these veins, mass ligation is often advisable. The middle lobe bronchus and the dorsal segmental bronchus of the lower lobe originate at about the same level. When the dorsal segmental bronchus is clamped and sutured, there is some danger of constricting the middle lobe bronchus.

Technique of Resection of Left Lower Lobe and Lingula (Figs. 234 to 237)

In a discussion of segmental pulmonary resection Clagett and Deterling emphasize the importance of careful dissection along cleavage planes created by bronchovascular divisions of the lung By this method the use of traumatizing clamps on the lung tissue is avoided. These authors describe their technique of removal of the left

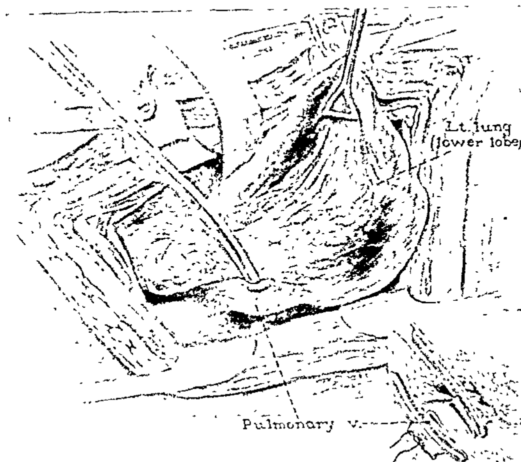


FIGURE 235. Technique of left lower lobectomy and lingulectomy (*continued*) The lung has been retracted anteriorly and the inferior pulmonary vein exposed. (Clagett and Deterling· J. Thoracic Surg , Vol. 15.)

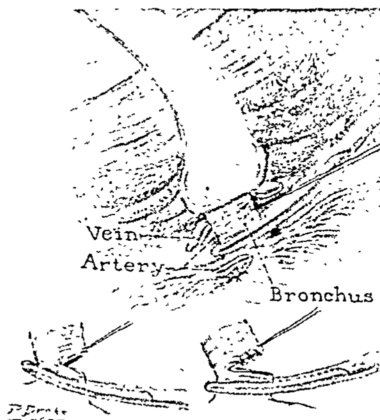


FIGURE 236 Technique of left lower lobectomy and lingulectomy (*continued*). Steps in the division and closure of the bronchus Care must be taken not to leave a long bronchial stump. (Clagett and Deterling. J. Thoracic Surg , Vol 15.)

lower lobe and lingula. After freeing the hilar structures, the vessels are first ligated and divided. As traction is made on the bronchus, it is divided and closed by the method of Sweet. The lingular bronchus is mobilized and clamped lightly. The lung is then inflated under positive pressure to show the integrity of the left upper lobe and to outline the lingula. Where the lingular bronchus arises from the left upper lobe bronchus the vessels are ligated and divided. The lingular bronchus is divided, and the proximal stump is ligated. The distal stump is used for traction as the lingula is removed. The lingula can usually be dissected free along a relatively avascular plane. As the lingula is removed, individual vessels and broncholes are clamped and ligated along the line of cleavage. The hilar stump is covered with pleura.

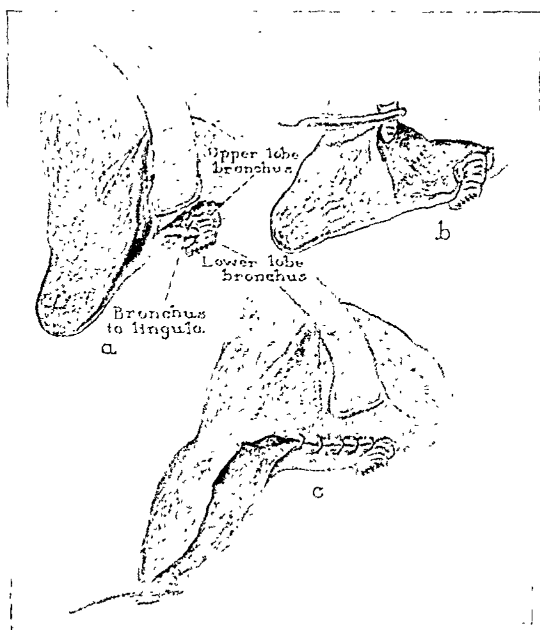


FIGURE 237 Technique of left lower lobectomy and lingulectomy (*concluded*) The lingular bronchus has been identified, clamped, divided and sutured The lingular artery has been previously divided, as has the lingular vein, which enters the superior pulmonary vein anteriorly The intersegmental plane is identified by inflating the remaining portion of the upper lobe and the pleura along the plane incised. By gentle traction and blunt dissection the lingular segment can be separated cleanly from the remainder of the upper lobe. (Clagett and Deterling: J. Thoracic Surg, Vol 15)

PNEUMONECTOMY

Indications

Total pneumonectomy is the operation of choice for malignant neoplasms of the lung. It may be indicated in selected cases of benign tumors, nontuberculous pulmonary infections, extensive bronchiectasis and in selected cases of tuberculosis.

General Considerations

Before operation, careful evaluation of the patient's cardiopulmonary reserve is necessary. Since injury to one of the pulmonary vessels may result in severe blood loss, provisions for adequate blood replacement should be made. It is wise to start an infusion of 5 per cent dextrose solution at the beginning of operation, using a large-gauge needle. In many instances an ankle cut-down should be done so that blood can be replaced rapidly if necessary. Care must be exercised in the administration of fluids and blood to prevent overloading the cardiovascular system, which is placed under considerable strain when one lung is removed. Saline solution should be avoided. The complications of total pneumonectomy that may be anticipated are operative shock, mediastinal flutter, edema of the contralateral lung, primary and secondary hemorrhage from the pulmonary stump, pleural effusion, tension pneumothorax, infection of the pleura, opening of the bronchial stump and infection of the stump.

Earlier diagnosis and operation combined with improved anesthesia, blood replacement, antibiotics and better surgical technique have improved the rate of resectability and the number of five-year survivals in bronchogenic carcinoma.

Endotracheal anesthesia, using an inflatable cuff, should always be used. This ensures an airway and permits the easy aspiration of secretions during the operation. Frequent aspiration of the endotracheal tube during the operation is necessary.

The advantages and disadvantages of the three different surgical approaches are described elsewhere. The lateral position with a classic posterolateral incision is generally the most satisfactory and widely used approach.

Technique of Operation—Lateral Approach

With the patient lying on his side, the diseased side uppermost, a classic posterolateral thoracotomy incision is made. In most instances the fifth or sixth rib is removed subperiosteally and the pleural cavity entered through the base of the excised rib. When the thorax has been opened, all adhesions between the lung and chest wall are divided and the extent of the disease determined. When a histological diagnosis has not been established before operation, biopsy may be indicated. The first step in pneumonectomy is incision and reflection of the perihilar pleura. The order in which the pulmonary artery, bronchus and veins are handled varies somewhat with anatomy, nature of the underlying disease and position on the table. In the lateral approach the main pulmonary artery, superior pulmonary vein, inferior pulmonary vein and the bronchus are managed in that order. The technique of dissection, ligation and closure of these structures is described elsewhere. In the presence of suppurative disease, isolation and occlusion of the bronchus may be indicated as a first step to prevent spillage of purulent material into the normal tracheobronchial tree. On the right side it may be necessary to ligate and divide the superior pulmonary vein before ligating the artery in order to gain better access to the artery.

After removal of the lung the bronchial stump is repleuralized, and the pleural cavity is flushed out with warm physiologic saline solution. Some authors advise crushing the phrenic nerve, although this step is not considered necessary by others. The chest wall is then closed in layers without drainage. When the patient has been turned to the supine position, the intrapleural pressure on the operated side should be adjusted to normal or a slightly negative value. This may be done by inserting a needle into the cavity through the second anterior intercostal space and withdrawing air until a slightly negative pressure is obtained.

Technique of Operation—Anterolateral Approach (Rienhoff) (Figs. 238 to 241)

The patient is placed on the operating table in a semirecumbent position with the arm on a support or held above the head. An incision is made over the third intercostal space extending from the costal cartilages to the anterior axillary line. The pectoralis major and intercostal muscles and pleura are then divided. The third and fourth ribs are spread apart with a self-retaining retractor. This procedure gives a good exposure of the lung hilum. Ochsner and DeBakey advise resection of the third rib to increase exposure.

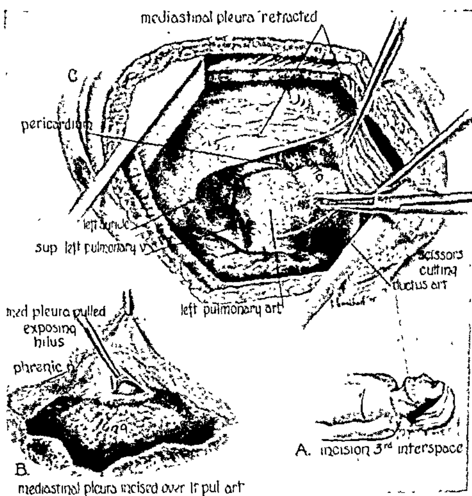


FIGURE 238 Technique of total pneumonectomy *A*, Line of incision in the third left interspace. This position on the table allows full expansion of the opposite lung. *B*, Exposure of the mediastinal surface of the upper lobe of the left lung The mediastinal pleura is incised, exposing the pulmonary artery. *C*, The mediastinal pleura is reflected, permitting dissection and exposure of aorta and left pulmonary artery (Rienhoff. Arch Surg, Vol. 32)

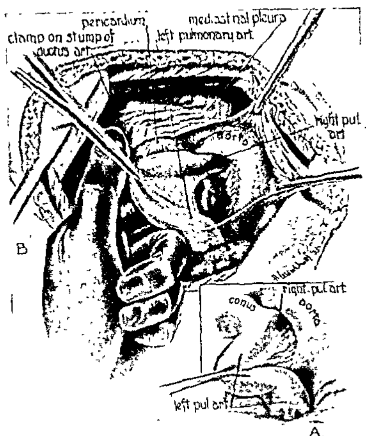


FIGURE 239 Technique of total pneumonectomy (*continued*). *A*, Dissection showing division of pulmonary artery into right and left pulmonary arteries outside the pericardium. *B*, Left pulmonary artery reflected downward by traction on the clamped stump of the ductus arteriosus. The index finger is passed under the left pulmonary artery with ease. (Rienhoff Arch. Surg, Vol. 32.)

Because of a difference in anatomy, resection of the right and left lungs will be considered separately.

Left Lung. The pulmonary artery and veins lie in front of the primary bronchus. The intrapleural portion of the pulmonary artery is short, and its wall is thin and easily torn. The three branches of this vessel are in intimate contact with the bronchus, and the large posterior branch may be torn when separating it from the bronchial wall Exposure of the artery is best obtained by incising the mediastinal pleura. The fibrous remains of the obliterated ductus arteriosus are divided, and the cut ends are used as tractors. The artery is freed from the aorta, bronchus, pulmonary vein and superior posterior portion of the pericardial sac. The artery is doubly ligated with silk in the suprapericardial mediastinal space between its branches and the origin of the right pulmonary artery.

The superior and inferior pulmonary veins are ligated within the pleural cavity. Isolation of the pulmonary veins exposes the bronchus. A high amputation of the bronchus is possible on the left. It is cut across not far from the bifurcation of the trachea. To secure sound healing, it is advisable to divide the bronchus high near the bifurcation of the trachea where the granulating area about the bronchus is in contact with the mediastinal areolar tissue and pleura. The incision is made oblique to the long axis of the bronchus, forming an angle of about 45 degrees with the superior border and about 135 degrees with its inferior medial border, so that the posterior membranous portion is somewhat longer than the anterior cartilaginous wall. Fine silk sutures are used to close the end of the bronchus, approximating the membranous

wall and the semicircular cartilaginous rings. Two parallel rows of through-and-through mattress sutures are placed proximal to the primary row.

All lymphatic glands about the vessels and bronchus are removed. Crushing the phrenic nerve will immobilize the diaphragm and aid in the obliteration of the pleural space. The bronchial artery and other small vessels are ligated. The mediastinal pleura is closed.

Right Lung. Pneumonectomy on the right is somewhat more difficult than on the left. The azygos vein is used as a landmark. Over and below this vein the mediastinal pleura is incised, and with careful blunt and sharp dissection the azygos vein superiorly, superior vena cava anteriorly and the superior pulmonary vein and posterior wall of the left atrium inferiorly, are exposed. Between the vein and bronchus the pulmonary artery and its three branches are identified. The superior pulmonary vein is doubly ligated intrapleurally. By retracting the vena cava and separating the artery from the vein and atrium, a ligature may be passed around the artery and tied extrapericardially. The inferior pulmonary vein is then ligated and divided. The mediastinal glands are then dissected out and the bronchus cleaned for division. The bronchus is sutured as on the left. After careful control of all bleeding points, the pleura is closed.

The thoracic wound is closed by encircling the third and fourth ribs with three or

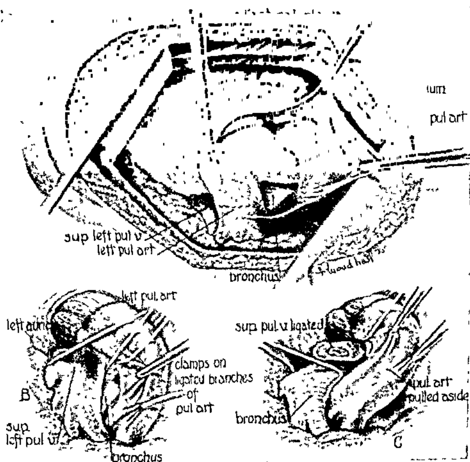


FIGURE 240 Technique of total pneumonectomy (*continued*) *A*, Left pulmonary artery exposed ready for ligation Dotted line shows point of election for ligation of the artery *B*, The points of extrapericardial ligation of the left pulmonary vein and artery, indicated by tapes *C*, Superior pulmonary vein has been ligated, exposing the bronchus Tape shows level for division of the bronchus within the extrapericardial mediastinal space (Rienhoff: Arch. Surg , Vol 32)

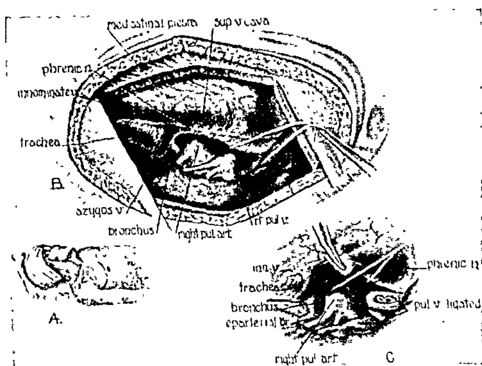


FIGURE 241. Technique of total pneumonectomy (*concluded*) *A*, Position of patient on the table for right pneumonectomy. Incision in third interspace. *B*, The mediastinal pleura has been incised, exposing the right pulmonary artery, right superior pulmonary vein, azygos vein and right primary bronchus. *C*, The superior pulmonary vein has been ligated and divided, exposing the first 2 ventral and anterior branches of the right pulmonary artery and the large descending posterior branch. The tape shows site of election for ligation (Rienhoff Arch Surg., Vol 32)

four strong silk sutures. The overlying muscle, fascia and skin are closed with interrupted silk sutures. Drainage is not advised. The accumulation of serum and plasma with later formation of fibrinous clot will aid in the obliteration of the pleural space. Drainage may later be necessary if infection develops.

The patient is placed in bed, preferably on the side operated upon, for twenty-four hours. The foot of the bed is elevated to aid bronchial drainage. Oxygen is usually advisable. Intravenous fluids must be given slowly to avoid strain upon the right heart.

Technique of Radical Pneumonectomy (Gibbon) (Figs. 242, 243, 244)

In recent years many authors have extended the classic pneumonectomy to include intrapericardial ligation of the hilar vessels plus block dissection of the lymph nodes. The resectability rate is increased considerably by using this technique. The method of intrapericardial ligation of vessels is described under a previous heading. The technique varies slightly between the right and left sides.

Right Side. An adequate right posterolateral thoracotomy incision is made and the extent of disease assessed by exploration. The mediastinal pleura is then incised from the apex of the chest down to the main bronchus. This incision is extended anteriorly to expose the pulmonary artery and posteriorly to expose the bronchus and carinal nodes. The azygos vein is then doubly ligated and divided, and the mediastinal pleura is elevated on either side. Care is taken not to injure the phrenic nerve. The vagus nerve is then ligated and divided just below the point where the recurrent laryngeal nerve passes around the right subclavian artery. By using the distal end of the vagus nerve for traction, the fat and lymph nodes overlying the anterior and

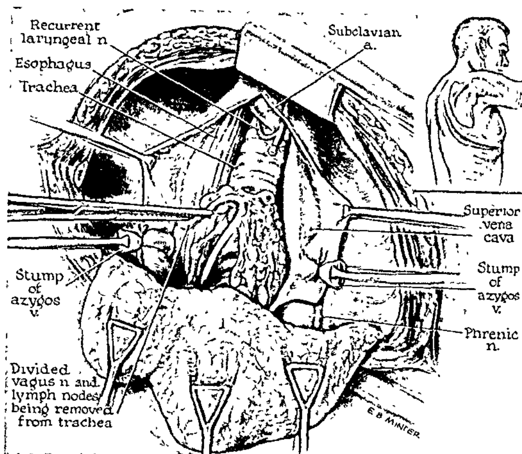


FIGURE 242 Right radical pneumonectomy. The pleura has been incised from the apex of the lung down to the bronchus. The azygos vein has been doubly ligated, divided and reflected with the pleura The vagus nerve has been divided just distal to the recurrent laryngeal branch and is being used for traction during removal of the superior mediastinal lymph nodes. (J Gibbon: Am J. Surg, Vol. 89)

lateral walls of the trachea are swept downward over the trachea, upper esophagus and superior vena cava.

The dissection is then carried anteriorly to the pulmonary artery and superior pulmonary vein. If the tumor involves the hilum, or if the pulmonary vessels are unduly short, the pericardium is opened to facilitate ligation and division of the pulmonary artery and superior vein. Otherwise the artery and vein are ligated and divided in the routine fashion. The lung is then retracted anteriorly, and the pulmonary ligament is divided up to the inferior pulmonary vein, sweeping out the lymph nodes and fat overlying the esophagus. The main trunk of the vagus nerve is again divided low in the thorax. The inferior pulmonary vein is then ligated and divided The subcarinal lymph nodes are then removed, beginning on the opposite main bronchus at a distance of 3 cm. from the carina, thus leaving the carina and main bronchus bare. A clamp is placed across the bronchus and the actual line of division made obliquely through the trachea itself so as not to leave a bronchial stump. The trachea and bronchial tree can then be aspirated through the open trachea if indicated. The wound in the trachea is then closed with interrupted sutures, taking care that the needle and sutures do not pass through the mucous membrane of the trachea. The suture line is then covered with any adjacent tissue available; the pleural cavity is flushed with saline solution and the incision closed in layers without drainage.

Left Side. After proper exposure the mediastinal pleura is opened from the apex of the chest to the lung hilum. The fat and lymph nodes overlying the left common

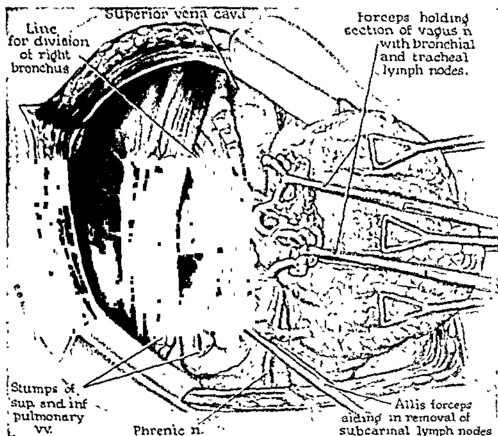


FIGURE 243. Right radical pneumonectomy, illustrating the removal of the inferior mediastinal and subcarinal lymph nodes (J Gibbon, Am J Surg, Vol. 89.)

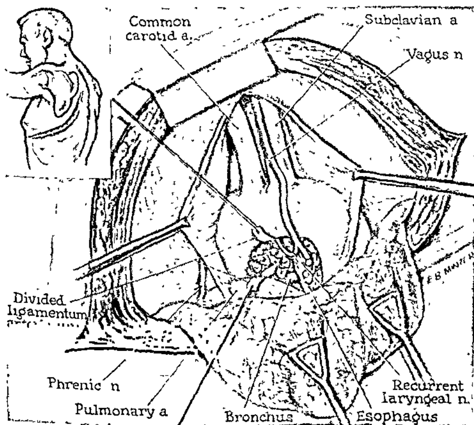


FIGURE 244 Left radical pneumonectomy The superior mediastinal dissection is somewhat more limited than on the right because of the presence of the aorta and the lower take-off of the *recurrent* laryngeal nerve. (J. Gibbon Am J Surg, Vol 89.)

carotid and left subclavian arteries are swept downward over the aortic arch, leaving these vessels and the vagus nerve cleanly exposed. The recurrent nerve is identified and the vagus ligated and divided just beyond this branch. The ligamentum arteriosum is divided, and the fat and lymph nodes lying anteriorly and lateral to the trachea and esophagus as high up under the aortic arch as possible are swept downward to the distal portion of the left main bronchus. The remainder of the dissection is carried out as on the right side, and in most instances it will be found advisable to open the pericardium for increased ease of handling the pulmonary vessels. The chest cavity is washed out with saline solution and the wound closed in layers without waterseal drainage, as in routine pneumonectomy.

MEDIASTINUM

SUPPURATIVE MEDIASTINITIS

Technique of Cervical Drainage

A foreign body which has penetrated the wall of the trachea or esophagus and caused infection should be removed, if possible, through the bronchoscope or esophagoscope. If the foreign body lies outside the trachea or esophagus, it is unsafe to use these instruments because of danger of increasing the trauma and infection.

Abscesses in the upper mediastinum may often be drained through *cervical incisions.* Pearse states that this is the logical approach for drainage of mediastinitis above the level of the sixth dorsal vertebra. The pointing of an abscess in the neck marks the point of incision. A cervical incision at the median border of the sternocleidomastoid muscle extending upward from the suprasternal notch will give exposure in many cases. To expose the upper mediastinum through such an incision, the sternocleidomastoid is retracted laterally and the anterior neck muscles medially. By blunt dissection the thyroid gland is exposed. It may be necessary to ligate the lateral veins and inferior vessels of the thyroid if the abscess is deep. Careful dissection is imperative to avoid injury to the trachea, esophagus, carotid and subclavian arteries, jugular vein, brachial plexus, recurrent laryngeal nerve, and lung. Unnecessary trauma must be avoided because of the danger of spreading infection to adjoining tissue spaces and fascial planes. Two to four drains of the cigarette or Penrose type should be introduced into the abscess. Hard rubber tubes are unsuited for such drainage because of the danger of blood vessel erosion from pressure. The wound is closed loosely about the drains.

When cervical drainage is inadequate, it should be supplemented by costal cartilage resection or rib resection with posterior mediastinotomy.

Technique of Anterior Mediastinotomy

An incision is made through all tissues down to the costal cartilage, which is removed from its attachment to the sternum to its junction with the rib. The abscess should be entered by careful blunt dissection. This may be facilitated by gentle exploration with an aspirating needle. In some cases it may be advisable to remove more than one cartilage or a portion of rib. Soft cigarette type drains are used.

Technique of Posterior Mediastinotomy (Fig. 245)

If mediastinitis is due to perforation of the esophagus, operation is indicated as soon as possible after the onset of the infection. Adams reported seven cases in which operation was done within three hours after the diagnosis was confirmed, without a death. Gastrostomy should be done for the administration of fluid and food.

The posterior mediastinum can be entered by resecting a portion of a rib with its transverse process. More than one rib may be resected to increase exposure. The site of the infection will determine the location of the rib to be resected.

After removal of 5 to 6 cm. of one or more ribs the pleura is carefully freed and retracted outward to expose the mediastinum. On the left the aorta and its branches and the thoracic duct, and on the right the vena cava, are to be avoided. An abscess may be located with an aspirating needle and usually entered by blunt dissection. Drainage should be adequate and continued until the deep infection has disappeared.

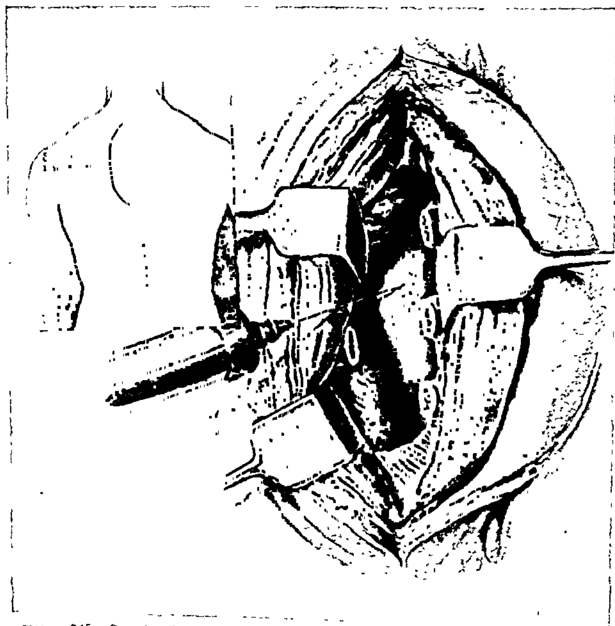


FIGURE 245. Sauerbruch technique of posterior mediastinotomy. Insert shows type of incision. Resection of proximal portions of 2 or 3 ribs with their transverse processes. Abscess may be located by careful aspiration. (Lerche. Lewis' Practice of Surgery, Vol. IV.)

MEDIASTINAL TUMORS

General Considerations

Cysts and tumors of the mediastinum, like such lesions elsewhere, should be removed as early as possible before such complications as infection, metastases, attachment to vital structures, and pressure symptoms have developed. The type of operation selected will depend upon size, location and estimate of malignancy or benignancy, and the general condition of the patient. Certain tumors or cysts high in the thorax may be removed through simple cervical incisions or a combined cervical incision and section of the manubrium. The deeper lying tumors require incisions through the bony thoracic cage. The classic posterolateral thoracotomy incision will suffice for most mediastinal tumors. The transverse transsternal incision and the midline sternum-splitting incision may provide better exposure of large anterior tumors. Figure 246 depicts some of the various incisions.

Dangers and Safeguards

The dangers of open pneumothorax may be minimized by using intratracheal positive pressure anesthesia. Late complications of mediastinal operations that may develop are infection of the wound, pleural effusion, empyema and tension pneumothorax. These should be anticipated and promptly treated.

The immediate dangers of mediastinal operations are shock, hemorrhage, functional disturbances of the heart, great vessels and lungs by pressure or traction, and fatal wounding of vital structures. A careful estimate of the patient's operability should be made previous to operation. Constant vigilance and careful technique by the anesthetist and operator are necessary to reduce the danger to a minimum.

Technique of Operation

Simple Cervical Incision. For tumors or cysts in the upper anterior mediastinum, Heuer recommends a simple cervical incision similar to that used for thyroidectomy (Fig. 246). The cervical fascia and anterior neck muscles are separated in the midline and the tumor extracted by careful blunt dissection and traction. If the tumor is too large to be delivered through a cervical incision and the upper thoracic aperture, the sternum may be divided as in the Sauerbruch approach.

Sauerbruch's Operation (Fig. 246)

Intratracheal positive pressure anesthesia is advisable for Sauerbruch's operation. The incision may extend downward from the cervical incision as described above or begin in the midline of the neck on a level with the cricoid cartilage and extend down the midline of the sternum to a level with the third chondrosternal articulation, curving to the right at this point over the third interchondral space. The muscles of the neck are divided in the midline, and the manubrium sterni is separated from the underlying tissues by blunt finger dissection. The third right interchondral space is opened, and careful finger dissection is made from below upward to meet the dissection from above. After separating the tissues from its posterior surface, the sternum is divided with saw or bone-cutting forceps down its center to a level with the third interspace. The sternal wound is then retracted to expose the upper mediastinum.

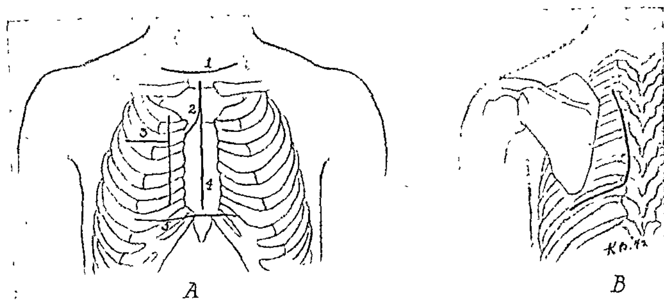


FIGURE 246. Incisions for approach to the mediastinum. *A*, *1*, Collar; *2*, Sauerbruch, *3*, parasternal and intercostal; *4*, Milton; *5*, Graham. *B*, Lilienthal

No technique is applicable to all tumors in this location. The pleura should be freed and retracted to avoid pneumothorax when possible. The growth is removed by careful dissection, keeping in mind the vital structures in this region. Certain growths, such as dermoid cysts, may be so intimately attached to the pericardium, great vessels or trachea that partial removal may be the only safe procedure.

The sternal wound is closed with sutures passed through holes bored in the sternal margins. The muscle and fascia may be closed with fine catgut and the skin with silk. Drainage is indicated above the suprasternal notch when there is much oozing or when the contents of a cyst or other source of infection is present.

Milton's Sternotomy (Fig. 246)

In Milton's sternotomy an incision is made over the midline of the sternum from the thyroid gland to the ensiform. Through the episternal notch the manubrium is separated from underlying structures by careful blunt dissection. The sternum is divided with a saw from the episternal notch to the xiphoid process. The xiphoid process is detached from the gladiolus. Retraction of the cut sternal edges exposes the anterior mediastinum. After completing dissection, the wound in the sternum is closed with chromic catgut passed through drill holes in the bone.

This is a formidable operation. The structures beneath the sternum are in danger during division of the sternum. The pleura may be wounded on either side. The peritoneum may be opened. Separation of the halves of the sternum stops costal breathing.

Friedrich's Transverse Sternotomy (Fig. 247)

A skin incision is made across the sternum 15 to 20 cm. long, at the level of the third ribs. The interchondral structures in the second interchondral spaces on each side of the sternum are divided and the sternum freed by blunt dissection. The sternum may be divided with a Gigli saw. The severed sternum is retracted to expose the underlying mediastinum. The intercostal incisions are extended as desired, and the costal cartilages or ribs may be cut across or excised to increase exposure. The mam-

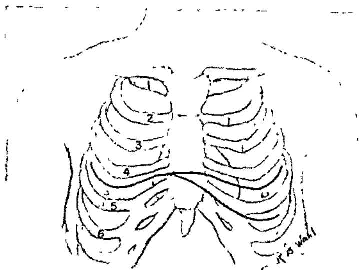


FIGURE 247. Diagram of the anterior chest, illustrating the course of transverse and oblique transsternal incisions used for the exposure and incision of large anterior mediastinal tumors. The level of the incision may be altered to suit the case and is useful in exposing the heart, pericardium and great vessels.

mary vessels should be severed and ligated. After completing the mediastinal dissection, the sternum is closed with silk or wire passed through holes bored in the bone.

The sternum may be sectioned by this method at other levels as desired for better exposure of lower portions of the mediastinum. Graham described a transverse incision suitable for large adherent tumors in the lower anterior mediastinum (Fig. 246). Positive pressure anesthesia is indicated to guard against the danger of opening the pleura on one or both sides.

Lilienthal's Posterior Mediastinotomy (Fig. 246)

The Lilienthal method of approach in posterior mediastinotomy is suitable for removal of tumors, exposure of the esophagus, or general exploration.

The patient should lie upon the side opposite the proposed approach, with the chest inclined slightly forward. This position may be maintained by strapping the thighs in a flexed position and supporting the chest with sandbags or special table attachments. Intratracheal differential pressure is preferred, since the pleura may be opened.

The operation may be performed high or low on either side as seems best suited to the case. To expose the lower posterior mediastinum, an incision is made over the ninth rib beginning about 15 cm. from the spine and extending backward to the edge of the long spinal muscles, then curving upward parallel to the spine over four or five interspaces. The ninth rib is resected subperiosteally from its angle outward the full length of the incision. The incision and rib resection may be shortened when only a small exposure is indicated. The pleura is peeled from the chest wall by gentle dissection, beginning behind the spinal stump of the resected rib.

After separating the pleura, the eighth rib is cut across with bone shears. The dissection is continued upward until the required number of ribs are severed to facilitate exposure. The severed ribs are retracted outward and upward as the pleura is further freed from the posterior mediastinum. The vertebral bodies, great vessels, esophagus and pneumogastric nerve are exposed. Great care is necessary in dissecting

to avoid injury to the pleura and vital structures as well as to the intercostal arteries and small veins. Bleeding from small wounded vessels may be difficult to control and obscures the operative field. If a tumor or cyst is found, the distortion of the normal anatomy increases the difficulties of dissection. To reach the upper posterior mediastinum, the dissection may be made from the sixth or seventh rib upward.

Drainage is advisable for infection or if oozing persists. Hard rubber tubes should not be used. An airtight closure should be made when possible, particularly if the pleura has been wounded. This may be done by careful suture of the intercostal muscles, rib periosteum, overlying muscles, fascia and skin.

Intercostal or Rib Resection Technique (Fig. 248)

Heuer recommended an intercostal incision for exposure of most mediastinal tumors. To increase exposure, a subperiosteal rib resection may be added, or the costal cartilages or rib ends may be divided. When the female breast overlies the ribs to be exposed, a curved incision should be made so that the intact breast may be reflected upward. The ribs are retracted by a self-retaining rib spreader. When possible, the parietal pleura is separated from the thoracic wall and mediastinum to expose the tumor. Since vital structures usually lie adjacent or adherent to the tumor, great care is required in dissection. After removal of the tumor all bleeding points are carefully ligated, and an airtight closure of the thoracic wall is made. This method shortens convalescence and produces a good cosmetic and physiologic result. Pleural effusion developing later may be aspirated. If trauma has been extensive, a snugly fitting tube may be passed through a stab wound between the ribs for waterseal drainage.

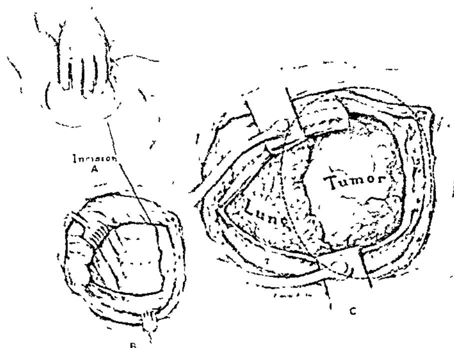


FIGURE 248 Technique of excision of anterior mediastinal tumor *A*, Type of skin incision used below the breast [illegible] intercostal incision and division of the fourth, fifth and sixth [illegible] ng tumor in its relation to displaced lung. (Adams, S. Clin.

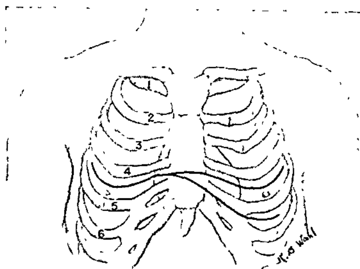


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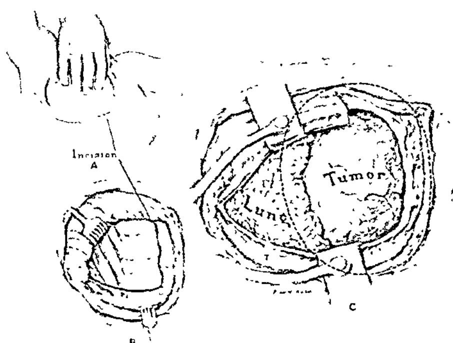


FIGURE 248 Technique of excision of anterior mediastinal tumor. *A*, Type of skin incision used below the breast. *B*, Ribs exposed, showing intercostal incision and division of the fourth, fifth and sixth costal cartilages *C*, Ribs separated, exposing tumor in its relation to displaced lung (Adams: S Clin. North America, Vol 26)

PHRENIC NERVE OPERATIONS

General Considerations

Interruption of the phrenic nerve either temporarily or permanently was formerly used in the management of pulmonary tuberculosis, but is used only rarely today. Interruption of the left phrenic has been used with success in the management of hiatus hernia, especially in patients on whom more extensive procedures cannot be done because of debility, age or intercurrent disease.

Technique of Phrenic Neurectomy (Fig. 249)

A small sandbag or pillow is placed between the scapulas, and the head is turned sharply away from the operative field. Local anesthesia is usually preferable. A light gas anesthesia may be used when the nerve is avulsed, since this is often painful. An incision 6 cm. long is made 2.5 cm. above and parallel to the clavicle, extending lateralward from the sternocleidomastoid muscle. Section of the platysma muscle and subcutaneous tissues exposes the clavicular portion of the sternocleidomastoid muscle. The sternocleidomastoid is retracted inward. Through the areolar tissue just external

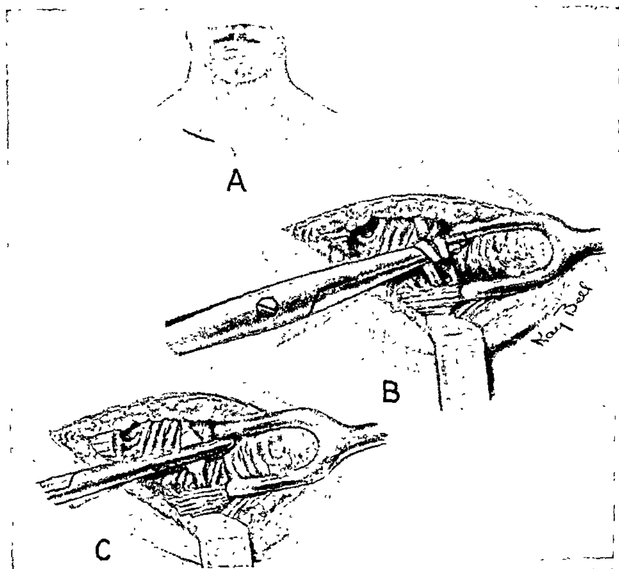


FIGURE 249. *A*, Skin incision for exposure of phrenic nerve *B*, Phrenic nerve divided and rolled on hemostat preparatory to avulsion. *C*, Phrenic nerve crushed with hemostat

to the jugular vein may be found the scalenus anticus muscle with its attachment to the first rib. If the omohyoid muscle is exposed, it should be retracted upward. The superficial cervical artery is avoided.

The nerve crosses the scalenus anticus muscle obliquely from above downward and inward and is readily seen beneath a thin fascial sheath. It is usually about the size of the lead in a lead pencil. Irritation of the nerve, causing referred pain to the shoulder region or contractions of the diaphragm, may aid in its identification. Avulsion or exeresis is done by first sectioning the nerve and then gently rolling it on a hemostat with a steady pull.

If only temporary paralysis lasting from four to six months is desired, the nerve may be crushed with a hemostat a distance of about 1 cm. This operation is believed by many surgeons to be more desirable than nerve destruction.

The fascia and platysma muscle are sutured with fine interrupted silk sutures. Mattress sutures of fine silk placed in the skin near the wound margins minimize scarring. These sutures may be removed on the third postoperative day.

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CHAPTER 10

The Breast

MAMMARY ABSCESS

Technique of Incision and Drainage of Breast Abscess

A simple subcutaneous or subareolar abscess is drained through a linear incision, radiating outward from the nipple. Incision into the areola should be avoided when possible to prevent injury to the lactiferous ducts.

To drain an abscess in the breast tissue, a radial incision is made directly over the abscess. The abscess cavity is carefully explored with the finger and any adjacent abscess pockets united into one single cavity. With a forceps in the cavity pointing toward the skin of the periphery, a counterincision is made, preferably in the dependent portion of the breast or at the breast margin. Through-and-through drainage is established by inserting one or more Penrose or cigarette drains. Ligatures may be required for bleeding vessels. Sutures are seldom necessary. Multiple incisions may be advisable for multiple abscesses.

A submammary abscess may be drained through an adequate curved incision at the lower breast margin (Fig. 250). If the abscess is deep or there are multiple abscesses, a curved incision along the lower breast margin may be made one third to one half of the breast circumference. Dissection is then carried through the subcutaneous fat and connective tissue plane and the breast lifted from the chest wall to expose its

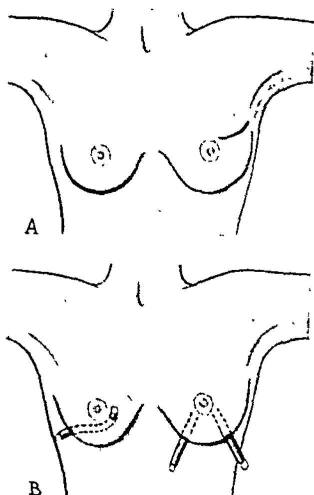


FIGURE 250. *A*, Incisions in the breast for drainage of simple abscess. *B*, Through-and-through and submammary drainage. (T. G. Orr in W. H. Cole: Operative Technic in General Surgery. New York, Appleton-Century Co.)

under surface. One or more abscesses may be drained through this incision. After placing rubber tissue drains to all abscess pockets, the wound is partially closed about the drains with interrupted silk sutures. A dressing is applied to support the breast.

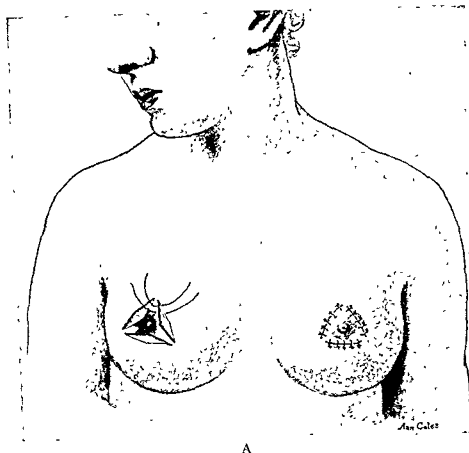
UMBILICATED OR DEPRESSED NIPPLE

General Considerations

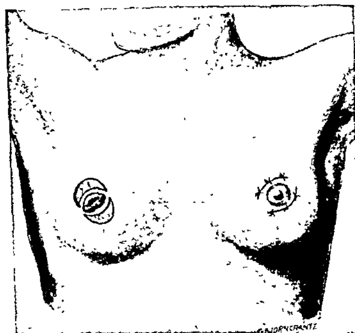
Developmental anomalies of the nipple resulting in invagination or umbilication may require a plastic operation to make nursing possible. The general plan of operation is to constrict the connective tissue about the nipple to hold the nipple in the normal position. This operation should not sever any of the ducts leading to the nipple.

Technique of Mammilliplasty for Depressed Nipple (Ashford)

The nipple is grasped with forceps and drawn outward to stretch the surrounding skin. Three spindle-shaped areas about the nipple are denuded with apices almost in contact (Fig. 251). *The line of incision should be about 1 5 cm from the nipple.* A purse-string suture of chromic catgut is passed through the denuded areas about the nipple in a zigzag fashion and tied. This puckers the connective tissue about the base of the nipple and prevents its depression. The denuded skin wounds are closed with silk.



A



B

FIGURE 251. *A*, Ashford's mammilliplasty for inverted or invaginated nipple. Three spindle-shaped areas are denuded about the nipple. When the skin is sutured, the nipple is drawn outward. *B*, Kehrer's mammilliplasty for umbilicated nipple. A semilunar area of skin is removed on each side of the nipple. When the wounds are sutured, the nipple protrudes. (Bickham: Operative Surgery.)

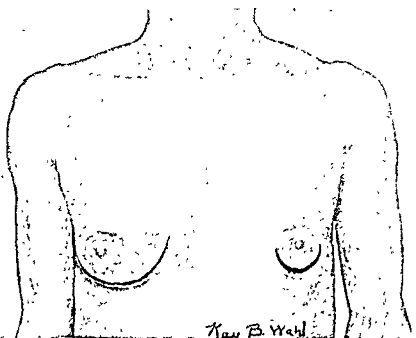


FIGURE 252. Incisions used for removal of breast for gynecomastia. *Right*, Incision made at breast margin *Left*, Incision at margin of areola for small breast.

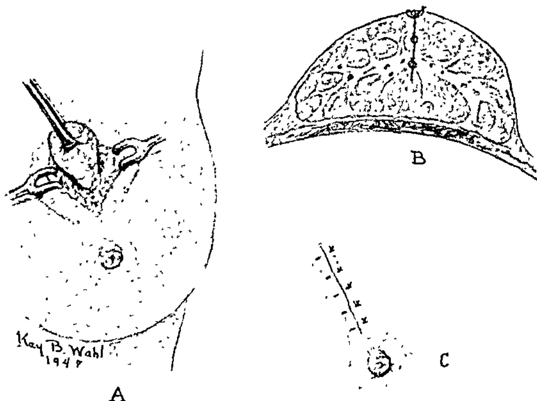


FIGURE 253 Technique of excision of benign tumor or cyst *A*, Wound radiating from the nipple is open with tumor exposed *B*, Cross section of breast showing method of closing wound in breast to obliterate all dead space *C*, Skin wound closed with interrupted vertical mattress sutures of silk.

For the slightly umbilicated nipple, the *technique of Kehrer* is applicable (Fig. 251, *B*). A double crescentic incision is made on each side of the nipple, denuding an area down to the fascia about 2.5 by 5 cm., as shown in the illustration. These two incisions are closed with interrupted silk sutures. By this method the depressed nipple is projected outward.

GYNECOMASTIA

General Considerations

Enlargements of the male breast may be due to endocrine disturbances, chronic mastitis, or neoplasms. Operation is indicated for persistent mastitis, neoplasms, and occasionally for cosmetic reasons. Radical mastectomy must be done if a malignant tumor is found. The nipple should be preserved when the breast is removed for mastitis or for cosmetic reasons.

Technique of Breast Removal with Preservation of the Nipple (Fig. 252)

If the breast is large, a curved incision is made at its lower margin, and all the breast tissue is excised except the nipple and areola. If the breast is small, the incision may be made along the lower margin of the areola. The skin is closed with fine silk or cotton, and a pressure dressing is applied.

MASTITIS AND BENIGN TUMORS OF THE BREAST

Technique of Excision of Benign Tumor or Cyst

This operation should be done with least possible trauma to the breast tissue.

Make an incision slightly longer than the diameter of the tumor radiating from the nipple (Fig. 253). If the tumor is encapsulated, dissect and remove the mass with its capsule. If it is not encapsulated, as in the case of a cyst, remove a thin portion of adjacent breast tissue with the cyst. Suture the incised breast tissue and subcutaneous tissue with fine catgut or silk, grasping as little as possible of the glandular structure in the sutures. Close the skin incision without drainage.

To avoid visible scarring, a curved incision may be made below the breast in the skin fold (Fig. 252). Dissect the breast upward from the chest wall, and incise the breast tissue over the tumor radiating from the center of the breast. Dissect the tumor from the breast tissue, and close the skin with drainage. Avoid collection of exudate beneath the breast by applying a firm dressing.

Technique of Excision of Intraductal Papilloma (Fig. 254)

Intraductal papillomas causing bleeding from the nipple should be explored. Local excision is sufficient if the papilloma is benign. If there is evidence of malignancy, a complete breast amputation must be done.

The duct containing the papilloma may be located by digital compression and in some cases by inserting the eye-end of a sewing needle into the bleeding duct (Babcock). When the bleeding duct is located, it is completely excised through an incision made at the margin of the areola or radiating outward from the areola.

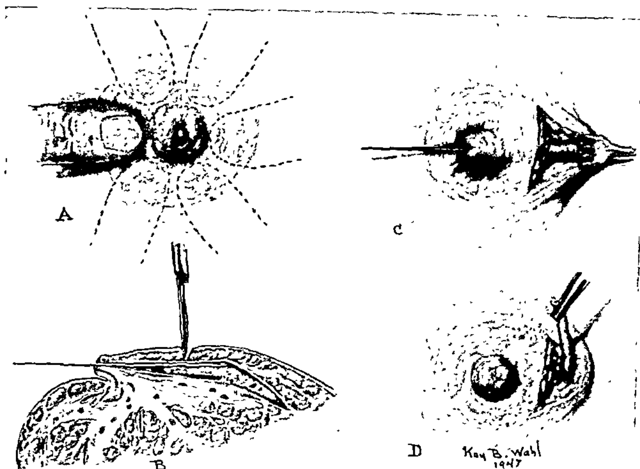


FIGURE 254. Technique of excision of intraductal papilloma. *A*, Method of using digital pressure to locate the diseased duct. *B*, Babcock's method of locating the diseased duct by inserting the eye-end of a sewing needle. *C*, Incision at the areolar margin with exposure of dilated duct *D*, Excision of the diseased duct.

Technique of Simple Mastectomy

Make an elliptical incision about the breast, preserving sufficient skin to close without tension (Fig. 255). Undercut the skin to the edge of the breast tissue, and dissect the breast free from the underlying muscles and the chest wall. Ligate all bleeding points carefully with fine plain catgut or silk. Close the skin without drainage, and apply a firm dressing.

THE PENDULOUS HYPERTROPHIC BREAST

General Considerations

In general, there are four types of pendulous breasts. These are true hypertrophy, congenital hypertrophy with one breast larger than the other, fatty hypertrophy, and hypertrophy due to mastitis.

Plastic operation is not indicated in every case of hypertrophied breast. Maliniak states that the degree of deformity, the age of the patient and her attitude toward the malformation, the influence of the abnormality on her health and the extent to which it interferes with social and economic life should be carefully considered before operation is advised. Amputation is the operation of choice in true hypertrophy. Operations upon other types offer hope of correction in well selected cases.

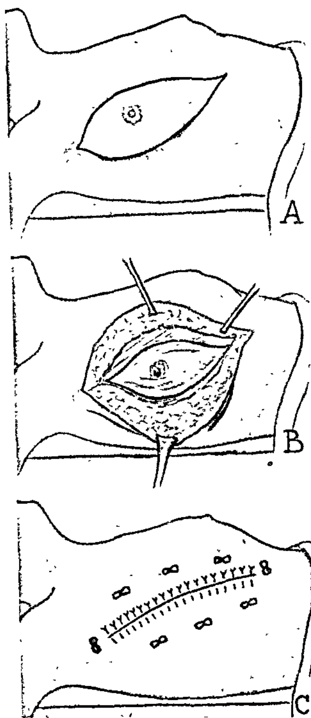


FIGURE 255. Technique of simple mastectomy. *A*, Skin incision *B*, Skin flaps reflected. *C*, Wound closed. Deep coaptation sutures are used to prevent collection of serum in these flaps (T. G. Orr in W. H. Cole Operative Technic in General Surgery. New York, Appleton-Century-Crofts, Inc)

Dangers and Safeguards

Breasts do not lactate after plastic repair. This is usually not a serious complication, since a pendulous hypertrophic breast is rarely capable of normal function.

Much difficulty may be experienced in obtaining smooth, symmetrical breasts after operation. Careful measurements of breasts and skin flaps should be made and the entire procedure carefully planned before making any incisions. The blood supply must be preserved to prevent necrosis of the skin. Any torsion of the breast pedicle may interfere with its blood supply. Clean-cut incisions and painstaking suturing will reduce scarring. Properly placed pressure dressings will maintain approximation between the skin flaps and underlying tissues and prevent the accumulation of serum.

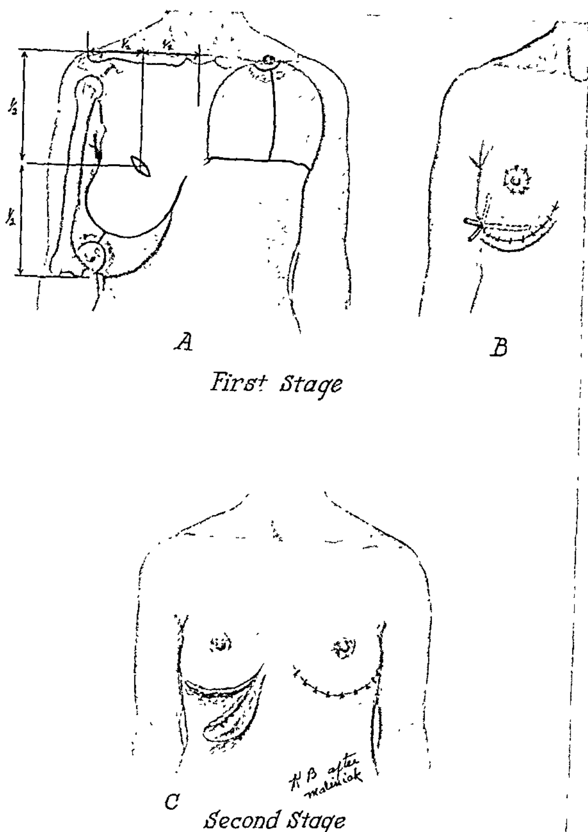


FIGURE 256. Two-stage method of repair of hypertrophic breasts *First Stage: A*, Horizontal lines are drawn across the clavicle, through the elbow joint and halfway between these lines A vertical line is drawn from the middle of the clavicle to intersect the middle horizontal line. Where these lines intersect is the new location of the nipple Incision lines shown on the upper and lower surfaces of the breast outline the skin areas to be removed *B*, Nipple sutured into its new location. Skin of breast closed, showing drainage in end of wound *Second Stage C*, Excessive skin beneath breast is removed (After Maliniak: Arch. Surg , 1935)

Technique of Plastic Operation for Pendulous Hypertrophic Breast (Fig. 256)

First Stage. The operation is planned by making careful measurements of the breast. A circular incision is made around the areola. Above the nipple a concave incision is made from one side of the submammary fold to the other. A flap is then separated upward as high as the second interspace, and a circular opening is cut at a predetermined measured point into which the margins of the areola are to be sutured. The upper pole of the breast is fixed to the pectoral fascia. Excess skin is then removed from the breast, and the areola is sutured into the circular opening in the upper flap. The first stage of the operation is completed by suturing the upper to the lower breast flap. Drainage at the angles of the incision for twenty-four hours will prevent accumulation of serum.

If both breasts require operation, the first stage may be done on each side at the same time.

Second Stage. In four to six weeks the excess skin, fat and glandular tissue are removed from below the breast by making a crescent-shaped incision in the submammary fold.

CARCINOMA OF THE BREAST

General Considerations

The female breast has an abundant blood supply chiefly from branches of the internal mammary, intercostal and axillary arteries. The lymphatic drainage from the breast is important, since tumor cells spread first along lymphatic channels to the neighboring lymph nodes. Cutaneous lymphatics of the anterior thoracic area drain into the axillary, supraclavicular and opposite axillary nodes. Lymphatics from the mammary gland proper drain into the axillary, retrosternal, retropectoral, deep cervical, and paramammary nodes. Lymph nodes of adjacent systems that may become involved in carcinoma of the breast are deep cervical, opposite axillary, diaphragmatic, hepatic, supraxiphoid, upper brachial, intercostal and inguinal. The lymphatic vessels beneath the skin also serve as pathways for the spread of cancer cells (Fig. 257).

Malignant tumors of the breast grow more rapidly and are a greater hazard during pregnancy. In general, the younger the individual, the more rapidly a cancer of the breast will grow. This rapidity of growth makes the prognosis more grave in this group, and Haagenson considers them not to be candidates for radical surgery. Radiation castration has been recommended by some for women with carcinoma of the breast developing before the menopause. This is thought to inhibit growth of the carcinoma and also prevent subsequent pregnancy with its hazard of stimulation of cancer cells to more rapid and infiltrative growth. There is some question at present of validity of this recommendation.

Malignant breast tumors are now usually treated by what has been popularly termed the *radical breast amputation.* The operation has been designed to remove not only the entire breast with the tumor, but also the regional lymphatic glands, muscle and fascia in which metastases are likely to occur relatively early in the course of the disease.



FIGURE 257. Location and arrangement of axillary and parasternal lymph nodes Routes of lymphatic drainage from the breast to these nodes. (Horsley and Bigger. Operative Surgery, C. V. Mosby Company.)

No single skin incision is applicable to all types of breast tumors. The incision should be so designed that it will avoid any tumor tissue and if possible leave intact sufficient skin so that reflected skin flaps may be closed without tension. In some instances the area of skin involved by the tumor may require modification of the skin incisions shown here to avoid the growth. When large areas of skin are removed with the breast, the denuded area should be covered at once by split skin grafts taken from the outer surface of the thigh.

The general plan of the *Halsted operation* is now followed by most surgeons. This *includes a complete removal of the breast with a wide area of skin, the pectoralis* major and minor muscles and a careful dissection of all the axillary contents, leaving the axillary vessels and nerves free of tissue. These tissues are removed in one mass to avoid dissection through cancer cells.

Dangers and Safeguards

Removal of tissue for biopsy is justified when an accurate clinical diagnosis cannot be made. Whether or not removal of such tissue may result in dissemination of carcinoma cells is still a controversial subject. If malignancy is seriously considered, the danger of cellular dissemination may be reduced by excising the entire growth with a margin of normal surrounding tissue, or by promptly instituting the radical operation

With reasonable care danger of excessive hemorrhage with subsequent shock is

not great. If hemostasis is careful, adequate support may be maintained by intravenous infusion of 5 per cent dextrose. Whole blood may prevent the development of shock when blood loss is excessive.

The *axillary dissection* is the most difficult part of a radical breast operation. It should be done with extreme care so that no cancer tissue may be left attached to the nerves or vessels. Injury to the axillary vessels, brachial plexus, and the nerves supplying the subscapularis, serratus magnus and latissimus dorsi muscles must be avoided. It is usually not practical to attempt preservation of the intercostobrachial nerve. Careful control of all bleeding with fine ligatures reduces the chance of infection and promotes smooth healing.

After operation, *serum* may collect beneath the skin flaps. Collections of serum delay healing, increase scar tissue, and predispose to infection. Careful approximation of the flaps to the underlying surfaces of the chest wall by the use of mattress sutures tied over buttons or short lengths of rubber tubing will tend to prevent this complication. If a collection of serum is discovered, it should be promptly and completely evacuated.

Contractures may result from the organization of blood clot, the placing of scars across the axilla from the chest to the arm, by scarring due to infection, injury to nerves, and delay in exercise and use of the arm. Motion of the shoulder should be started on the fourth or fifth postoperative day and gradually increased when the skin flaps become adherent. By the time healing is complete, the patient should be able to place the hand easily on the top of the head.

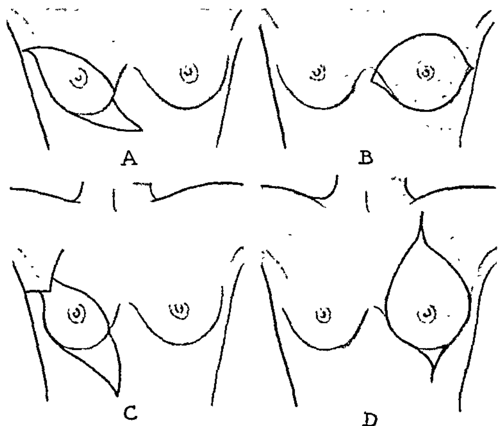


FIGURE 258 Types of incision for radical mastectomy. These *incisions all* prevent scar formation across the axilla to the arm *A*, Oblique, slightly S-shaped incision (Orr, Jr.). *B*, Transverse incision (Stewart) *C*, Incision forming triangular axillary *skin flap* (Orr). *D*, Vertical incision (Halsted). (T. G. Orr in W H Cole. Operative Technic in General Surgery. New York, Appleton-Century-Crofts, Inc.)

Postoperative *swelling* of the arm is a common complication when the axillary dissection has been complete. Swelling of the arm will be minimized by avoiding infection and accumulations of serum in the axilla. Late swelling of the arm may mean recurrence of the carcinoma in the axilla.

The immediate death rate following radical breast amputation is low for an operation of such magnitude. It should not exceed 1 or 2 per cent.

The percentage of five-year arrests following complete removal of the breast and axillary contents has varied widely in different clinics. For those patients having no demonstrable axillary involvement, 70 to 80 per cent may be alive at the end of five years. If the axillary lymph nodes are involved, five-year arrests usually range between 45 and 55 per cent.

Technique of Radical Mastectomy (Figs. 258 to 263)

A gas anesthetic is satisfactory. The patient is placed on the operating table with the arm extended on a support at a right angle to the body. This position will give proper access to the axilla. The type of skin incision depends upon the extent and location of the growth. The removal of wide areas of skin necessitates skin grafts to cover the defect. Many incisions have been described, no one of which is suitable for all cases. The incisions of Stewart, Halsted and Orr (Fig. 258) prevent the forma-

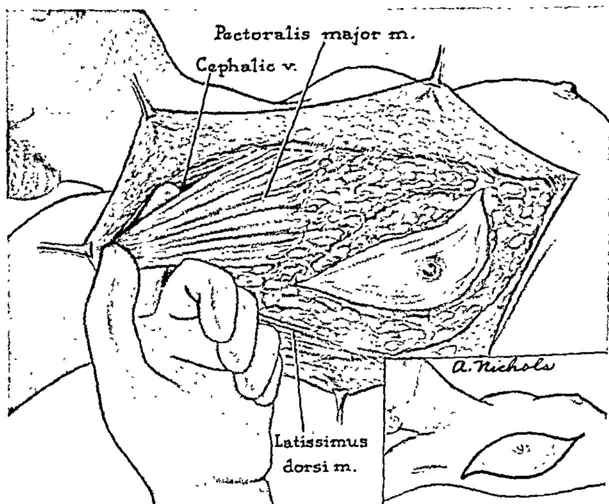


FIGURE 259 Technique of radical mastectomy. The skin flaps have been dissected The pectoralis major muscle has been exposed ready for section near the humerus (T G Orr in W. H. Cole: *Operative Technic in General Surgery* New York, Appleton-Century-Crofts, Inc.)

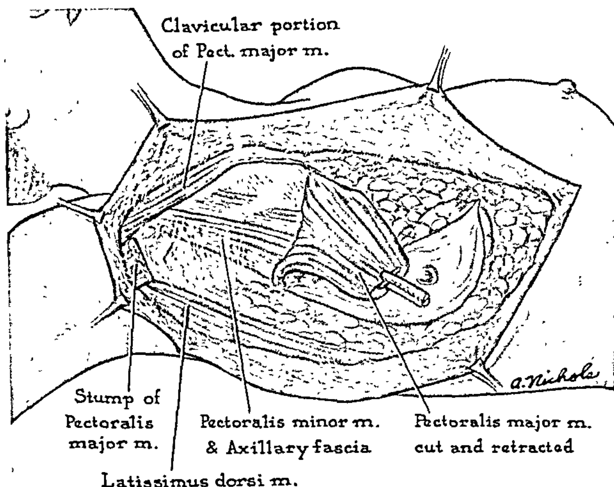


FIGURE 260 Technique of radical mastectomy (*continued*). The pectoralis major muscle has been divided and retracted, exposing the pectoralis minor muscle and pectoral fascia. (T. G. Orr in W. H. Cole. Operative Technic in General Surgery. New York, Appleton-Century-Crofts, Inc.)

tion of scar tissue across the axilla from the chest wall to the arm. A choice of these incisions must depend upon the location and size of the breast tumor, the shape of the breast and the presence of metastases.

The Orr II incision is here described (Fig. 258). This incision begins below the axilla at a level equivalent to the lower left margin of the anterior axillary fold and is transverse in direction. It extends medially to surround the breast and curves inferiorly and medially with an S-shaped configuration to terminate over the area overlying the upper portion of the rectus abdominis muscle (Fig. 258). Since no triangular flaps are constructed, the danger of necrosis at their apices is eliminated.

The skin flaps are undercut medially to the midsternal line, superiorly to the clavicle, and laterally to the anterior edge of the latissimus dorsi. This provides adequate exposure of the axilla and its contents. The pectoralis major and minor muscles are severed near their attachments and retracted downward with heavy hemostats. This dissection exposes the axillary fat and fascia covering the axillary vessels and nerves. All tissue is carefully dissected from the vessels and nerves from above downward, both anterior and posterior, exposing the chest wall and medial surface of the subscapularis muscle.

Branches of the great vessels are carefully ligated when exposed. Hemostats are not permitted to remain attached to vessels leading into the large vein so that injury to this structure may be carefully avoided. The intercostobrachialis nerve and nerves

Clavicular portion of Pectoralis major
Stripping off Rectus sheath
Thoracoacromial a. & v.
Brachial plexus
Stump of Pectoralis major m.
Axillary a. & v.
Subscapularis m.
Thoraco-dorsal n.
Long thoracic n.
Latissimus dorsi m.
A. Nichols

FIGURE 261.

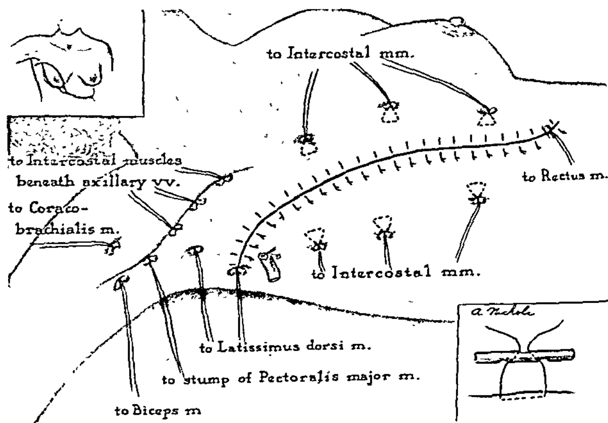


FIGURE 262

to the pectoral muscles are removed with the axillary contents. Great care should be taken not to damage the subscapular nerve supplying the subscapularis, the thoracodorsal supplying the latissimus dorsi, and the long thoracic supplying the serratus anterior muscles. These nerves lie deep against the chest wall and can easily be preserved.

As soon as the axillary contents are dissected free, the entire breast, the axillary contents and all underlying structures down to the chest wall and the anterior fascia down to the rectus abdominis muscle are removed in one mass. The many bleeding vessels are carefully clamped and ligated with nonabsorbable suture material or closed by coagulation with electrocautery. Those vessels along the medial border of the sternum which communicate with the internal mammary artery are probably best occluded with suture ligatures.

FIGURE 261. Technique of radical mastectomy (*continued*). The breast, both pectoral muscles, axillary contents and fascia of rectus muscle have been removed in one mass The long thoracic and thoracodorsal nerves have been preserved. (T G. Orr in W H. Cole Operative Technic in General Surgery. New York, Appleton-Century-Crofts, Inc)

FIGURE 262. Technique of radical mastectomy (*continued*) Coaptation mattress sutures have been placed to hold the skin flaps in contact with the chest wall and the apex of the axilla The coapting mattress sutures are placed in such a manner as to reduce tension on the skin margins (T G. Orr, Jr.: Am. Surgeon, Vol 22.)

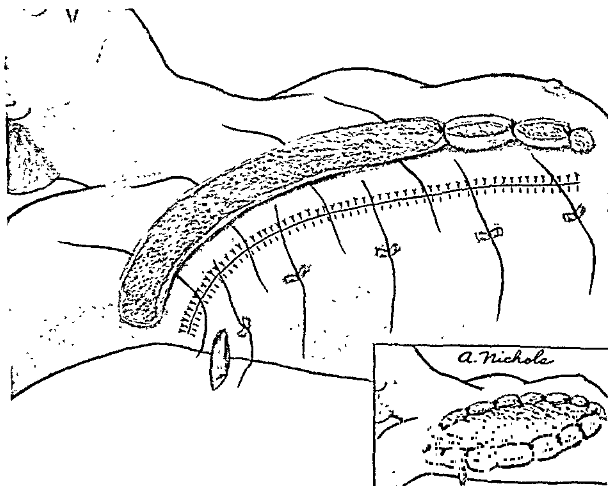


FIGURE 263 Technique of radical mastectomy (*concluded*) The ends of the coaptation sutures have been used to tie mechanic's waste in place over the suture line Mechanic's waste is used as a pressure dressing. Inset shows complete plan of dressing (T. G. Orr in W. H. Cole: Operative Technic in General Surgery New York, Appleton-Century-Crofts, Inc)

Before approximating the skin edges, basting mattress sutures of heavy silk or cotton are placed through the *skin and into the chest wall or any of the adjacent* muscles and tied in order to obliterate dead space and reduce tension on the skin margin (see Fig. 262). The skin flaps are then closed with interrupted sutures of either silk or cotton. A Penrose drain is inserted into the axilla and brought out through a stab wound inferior to the incision. This drain should be removed at the end of twenty-four to forty-eight hours, depending upon the quantity of drainage accumulated on the dressing.

The type of dressing used is important from the standpoint of rapid healing and future function. The axillary skin is pressed deeply into the axillary space and held in place with basting sutures passing into the chest wall and into the subscapularis muscles. Large masses of mechanic's waste wrapped in gauze are tied in place with the long ends of the basting sutures previously described. The remainder of the area involved in the dissection is covered with loose mechanic's waste and abdominal dressing pads. The entire dressing is held in place with elasticized bandage involving the entire chest wall and shoulder on the appropriate side.

Any accumulation of serum beneath the skin flaps should be aspirated. The axillary mattress sutures may be removed in five to seven days, and the skin sutures at the end of seven days. Motion at the shoulder is started on the fourth or fifth day and daily increased until full range is obtained by the time healing is complete.

Technique of Extended Radical Mastectomy (Ariel)

Recently much interest has been manifested in extending the classical radical mastectomy to include removal of the internal mammary chain of lymph nodes in continuity with the axillary contents and breast proper. This is considered particularly appropriate for those carcinomas occupying the medial superior aspects of the breast.

Preliminary preparation of the patient on the operating table is the same as in

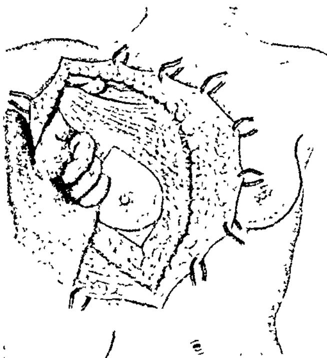


FIGURE 264 Illustrating the separation of the clavicular and sternal portions of the pectoralis major muscles subsequent to the development of fixed skin flaps The index finger is inserted under the sternal portion, which will then be severed at the humeral attachment The pectoralis major is then dissected inferiorly at its superior sternal attachment to expose *the first interspace* (I. M. Ariel Surg, Gynec & Obst., Vol. 100.)

the classic operation. The incision made is one best suited to the location of the tumor. The skin flaps are developed medially to the contralateral border of the sternum, laterally to the anterior edge of the latissimus dorsi muscle, and superiorly to the clavicle. The pectoralis major muscle is then separated from its clavicular portion, and its insertion is severed from the humerus and the dissection carried medially.

The first intercostal space is then exposed and the intercostal muscle divided 2 cm. lateral to the costosternal junction. This incision opens the chest wall and allows the index finger to be inserted through the opening and to identify the pulsations of the mammary artery. This vessel is then ligated, as is the internal mammary vein. The second rib is then severed with an appropriate rib cutter. Incision is then extended inferiorly to sever the third and fourth ribs with the muscles of the first, second, third and fourth inner spaces. The incision then extends laterally, and the internal mammary vessels are then ligated and severed at the distal point of excision. The chest wall flap thus formed may be reflected laterally so that the mediastinum, lungs and subclavian artery may be explored. Dissection within the chest cavity can then be carried superiorly in an effort to remove all internal mammary nodes up to a level of the first interspace. The flap of chest wall is next separated by a parallel vertical incision made along the pleural surface of the chest wall several centimeters lateral to the internal mammary vessels. This segment of chest wall is now part of the operative specimen and is continuous with it. The remainder of the operation is completed in a manner identical with that previously described. A rubber catheter or chest drain is inserted through the sixth or seventh interspace through a stab wound and attached to a waterseal drainage bottle. The severed ribs are approximated to the sternum, using number 30 gauge stainless steel wire inserted through drill holes. The skin flaps are then closed in a manner previously described.

The chest drainage tube may be removed in twenty-four to forty-eight hours, depending upon the amount of serosanguineous fluid evacuated from the chest and also upon whether or not oscillations of the fluid level within the waterseal drainage

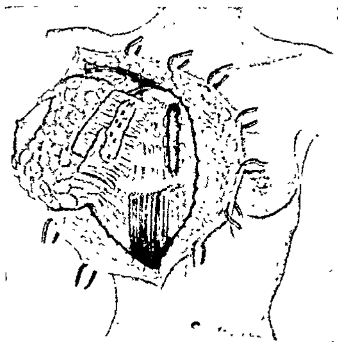


FIGURE 265. Illustrating excision of a block of chest wall in the parasternal region. An incision has been made in the first sternal space, the internal mammary vessels have been ligated, and about 1 5 cm. of rib margin on either side of the vessels have been excised (I. M. Ariel. Surg., Gynec & Obst, Vol 100)

bottle have ceased. Cessation of the oscillations indicates that the chest drainage tube is no longer functioning and therefore may be removed. Subsequent thoracentesis may rarely be required. Care must be taken in the immediate postoperative period to ensure adequate expansion of the lung on the involved side. Should any accumulation of serum beneath the skin flaps develop, aspiration should be used. Active motion in the shoulder and arm should be instituted no later than the fourth or fifth postoperative day and progressively increased to tolerance in order to regain the normal motion of the shoulder as rapidly as possible.

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CHAPTER 11

Circulatory System

OPERATIONS UPON THE ARTERIES

SUTURE OF BLOOD VESSELS

General Considerations

During recent years a great deal of progress has been made in the surgical management of peripheral vascular diseases. In addition to restoring continuity of arteries severed by trauma, large segments of diseased blood vessels as occur in aneurysm or occlusive vascular disease can be removed and continuity re-established by bridging the defect with arterial homografts, vein grafts or grafts constructed from various prosthetic materials

Vascular injuries causing complete severance of vessels or vasospasm may reduce the blood supply to a part and produce gangrene or crippling fibrosis. After such injuries every effort should be made to preserve the continuity of the artery involved. In rare instances involving larger vessels, when only a portion of the wall has been lost, the defect may be closed by lateral suture. In most instances, however, complete division of the involved vessel with end-to-end anastomosis to ensure maximum caliber of the vessel is preferable. When a portion of the vessel has been destroyed, or when end-to-end anastomosis is impossible, the gap can be bridged with vein, preserved arterial homograft or a prosthesis. If ligation is necessary, it should probably not be done in continuity, but rather the artery should be divided completely and each end ligated. Complete division of the vessel prevents peripheral arterial spasm and produces the best collateral circulation. Vasodilatation can be produced by blocking the sympathetic chain to the part with repeated injections of a local anesthetic agent or by sympathectomy.

Suture Material and Instruments

A vast variety of clamps, needle holders and other instruments, as well as special suture materials, have been studied and devised to facilitate arterial suture. In general,

stay sutures. The posterior sutures can be placed without rotation of the vessel by working from within the vessels. After release of the clamps there may be a slight amount of bleeding through the needle holes; however, this usually is controllable by pressure. It may be necessary to add a few interrupted sutures.

Everting Mattress Method (Fig. 271). The continuous everting mattress suture is preferred by some authors. This is easily applied when, as is usually the case, each side of the anastomosis may be rotated into view as it is sutured. By using this technique, the ends to be anastomosed are brought together with two or three interrupted mattress sutures. The vessels can then be rotated and the posterior sutures placed as illustrated. The sutures are placed about 1 mm. from the edge of the vessel and 1 mm. apart. The ends of the continuous sutures are then tied to the previously placed interrupted sutures. If rotation of the vessels is impossible, this type of anastomosis can be done by placing the posterior running mattress suture before the placement of preliminary holding sutures.

Double-Layer Method (Fig. 272). As previously stated, this method has application when there is a discrepancy in the size of the two vessels to be anastomosed, as when placing a graft after the removal of an aneurysm when there has been dilatation of the vessel above the aneurysm. By placing the first row of continuous everting mattress sutures in such a fashion that the distance between sutures is greater in the larger caliber vessel than in the smaller caliber vessel, this type of suture tends to produce stretching of the smaller vessel and compression of the larger vessel with a resulting invagination of the smaller into the larger lumen. When this suture layer has been placed, a second over-and-over running suture layer adds strength to the anastomosis and prevents leakage.

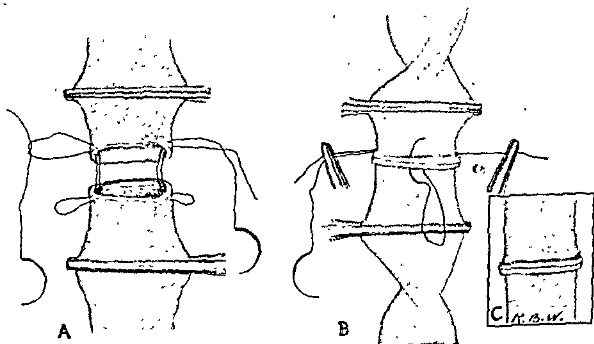


FIGURE 271 Arterial anastomosis using everting continuous mattress suture. *A*, The vessel ends are approximated with everting mattress stay sutures *B*, The anastomosis is then completed, using a running everting mattress suture. The vessel ends are rotated to permit placement of the posterior suture line *C*, Completed anastomosis

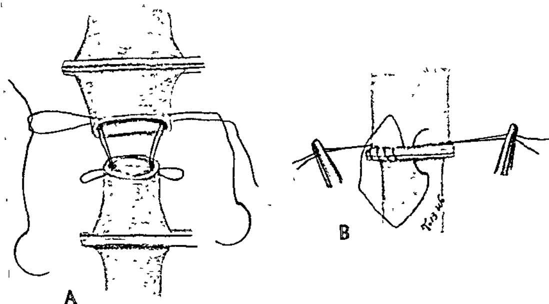


FIGURE 272. Double-layer method of arterial anastomosis which may be used when there is a disproportion in the sizes of the vessels to be anastomosed.

VESSEL SUBSTITUTES

The final status of the various methods and substances available for use as substitutes for arterial segments is far from settled. In general, the substances available and being used today are either preserved arterial homografts or vessel prostheses made from the various synthetics such as nylon, Orlon and Vinyon N. A segment of the patient's own vein of a suitable size may be used as an arterial substitute. In addition, heterografts—that is, blood vessels obtained from animals—are being studied for possible use as arterial substitutes in man. Arterial homografts must be obtained from the bodies of deceased persons and must be sterilized and preserved in a suitable fashion. This can be done by freeze drying or lyophilization. In addition to the problem of obtaining suitable quantities of homografts, there is also some question concerning the tendency of these grafts to develop atherosclerosis and aneurysms. Plastic fabrics fashioned by various means into tubular form have the great advantage of ready availability and offer no problems in sterilization or preservation. When used to bridge an arterial defect, these substances are soon covered on the inside with an intimal lining almost indistinguishable from that of a normal vessel, and the outside is covered with a fibrous coating. In general, this type of substitute has proved most satisfactory for the replacement of large vessels such as the aorta, but has been less satisfactory in the replacement of smaller vessels. As further study is carried out, it is anticipated that suitable materials for vessel substitutes will be widely available.

EMBOLECTOMY OF PERIPHERAL ARTERIES

General Considerations

Embolectomy is a surgical emergency. The time elapsing between the occurrence of embolism and operation is of great importance. In a review of 282 embolectomies

Pearse stated that 40 per cent of successful operative results may be expected in the first ten hours, 14 per cent in the second ten hours, and 8 per cent in the third ten hours. After the onset of gangrene, embolectomy is useless.

Almost every patient in whom embolism develops is acutely ill, and a high percentage operated upon successfully finally die of the disease causing the embolism. Even though the final outcome may seem somewhat discouraging, the operation of embolectomy has been definitely proved worth while to prolong life, conserve extremities and increase the patient's comfort.

A much higher percentage of success may be expected from embolectomy of the arteries of the upper extremity as compared to those of the lower extremity. It is also true that the indications for embolectomy are less definite in the upper extremity. Although many surgeons familiar with the subject recommend embolectomy of the axillary and brachial arteries, Lund expressed the opinion that embolectomy is not necessary or desirable in any case of embolism of the major arteries of the upper extremity. With the use of heparin, a much higher percentage of successes following embolectomy may be expected in the future.

An arterial embolus will most frequently lodge where a vessel divides. They are, therefore, commonly found in the axillary at the scapular branch, at the bifurcation of the aorta, at the branching of the iliac, at the profunda femoris in the femoral and at the division of the popliteal.

Technique of Embolectomy (Figs. 273, 274)

Since patients with arterial emboli are generally poor surgical risks, *local anesthesia* should always be used when possible. When exposing the aorta or iliac vessels, spinal anesthesia may be used.

The artery is usually exposed at the site of the embolus. The absence of the pulse below and its presence above the embolus are valuable guides and can usually be determined in the arteries of the extremities. Exposure of the aortic bifurcation and iliac vessels is considered unnecessary in many cases, since emboli may be removed from below through an incision in the femoral.

After exposing the artery, a rubber-covered clamp is placed above the embolus to control bleeding. Instead of the clamp, a narrow tape, rubber tubing or rubber band may be used. If the artery is well exposed, bleeding may be controlled by lifting the vessel on the tape or by twisting or tying the rubber band. The gentlest technique is required to avoid injuring the intima and thus predisposing to later thrombosis.

A longitudinal incision 0.5 to 1.5 cm. long is made in the artery. To hold the wound open with minimum trauma to the vessel wall, fine silk sutures are passed through each margin of the wound down to the intima and held with hemostats. The thrombus may often be extruded by gentle pressure or removed with forceps. If too friable and if elongated, the thrombus is more readily and completely removed by suction. Suction is satisfactorily applied by means of a catheter with the end cut off. Before inserting the catheter into the vessel, it should be dipped in sterile olive oil or petrolatum jelly. If the clot has been removed, there will be a back flow of blood from the distal portion of the artery which should be controlled by clamp or tape. The lumen of the vessel should be moistened at intervals with a 20 per cent solution of heparin in saline to minimize the tendency to postoperative thrombosis at the site

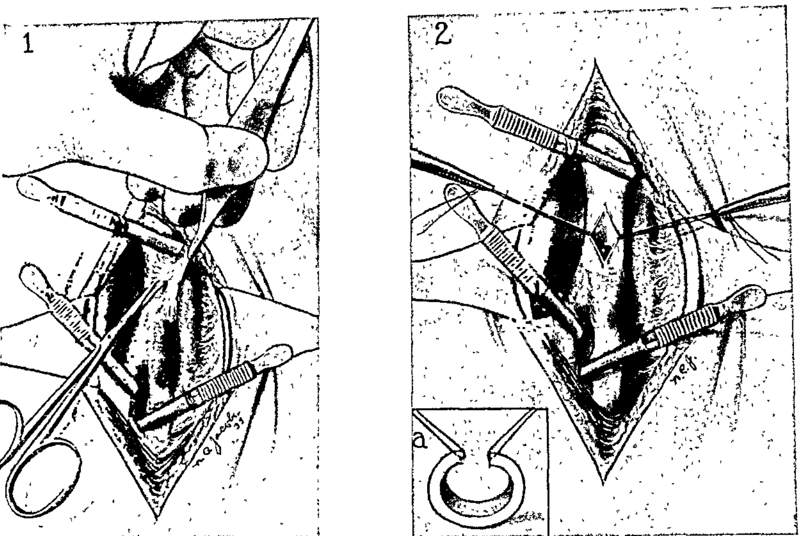


FIGURE 273. Technique of embolectomy. *1*, After locating the embolus, the adventitia is cut away at site of arteriotomy. *2*, Circulation is controlled with rubber-shod clamps. Opening into the artery made just above (or below) the embolus. Insert *a* shows how traction sutures are placed into but not through the vessel wall. (Pearse: Ann. Surg., Vol. 98, J. B. Lippincott Company)

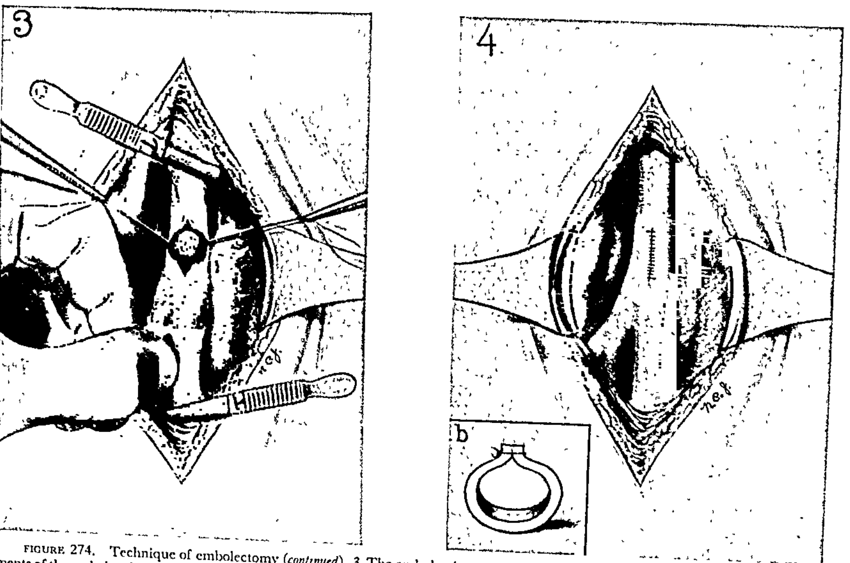


FIGURE 274. Technique of embolectomy (*continued*). *3*, The embolus is extruded by gentle compression of the artery. All fragments of the embolus should be carefully flushed out. *4*, Wound in artery closed with Carrel sutures of fine silk. A wider approximation of the intima is obtained with interrupted mattress sutures as shown in insert *b*. (Pearse: Ann. Surg., Vol 98, J. B. Lippincott Company.)

of the opening into the vessel. If back-bleeding is absent or sluggish, the artery may be exposed at some point distal to the arteriotomy and washed out from below with physiologic salt solution or Ringer's solution, by inserting a needle in the artery as suggested by Lund. The pressure on the artery above the incision should be momentarily released, allowing the blood to spurt to wash out particles of clot.

The artery is then closed with fine atraumatic arterial silk, using either a simple over-and-over continuous suture or a continuous everting mattress suture. Before closure a few cubic centimeters of 20 per cent heparin solution should be instilled into the arterial lumen. When closure is completed, the distal tape or clamp is released first, followed by the proximal tape or clamp. Bleeding from the suture holes can be controlled with light pressure, and only rarely is it necessary to insert additional interrupted sutures.

In most cases the administration of heparin to maintain the clotting time at fifteen to twenty minutes during the immediate postoperative period is indicated.

Kerr suggested that emboli involving the aortic bifurcation and iliac vessels be removed from below through an incision in one or both femorals. This procedure may be done with local anesthesia and the operative risk much reduced. He used suction with a well oiled, soft rubber catheter.

Excision of that portion of the artery containing the embolus (*arteriectomy*) may be done in rare cases. The rationale of this procedure is based upon the possibility of a lower incidence of gangrene by excision than by thrombosis at the same level.

TRENDELENBURG OPERATION FOR PULMONARY EMBOLISM

General Considerations

The early diagnosis of pulmonary embolism is of prime importance. This is sometimes very difficult. An operation of the magnitude of the Trendelenburg might lead to a fatality in cases that would recover with conservative treatment. With an accurate diagnosis of pulmonary embolism, the indication for operation may still be in doubt. Massive pulmonary embolism may kill promptly, whereas a smaller embolus will often not be lethal. Between these extremes the surgeon must select the relatively small number of patients upon whom the operation should be attempted. Nystrom states that

> as a rule, the Trendelenburg operation will be confined to those cases where the pulmonary embolism does not kill immediately, but only within the course of ten minutes, so that the operation can be regulated and planned at the right moment; that is, while the heart action and circulation have not been completely obstructed, although the certain death of the patient is imminent within a few moments *

The time limit within which embolectomy may be done for obstruction of the pulmonary artery has been given by Trendelenburg as forty-five seconds. Nystrom expressed the opinion that complete suspension of the circulation for nearly two minutes is not necessarily incompatible with the persistence of life. The importance of prompt and unquavering decision is evident in the words of Meyer that the decision to operate must be made "as quick as lightning in the sudden cases."

* Annals of Surgery, 92:498, 1930. J. B. Lippincott Company, publishers.

Dangers and Safeguards

This operation should not be attempted without thorough *preliminary preparation.* It is advised that the technique of the operation be first tried on the fresh cadaver to learn the essential anatomy. Instruments must be properly selected, sterilized, and ready for use at a moment's notice. Not only the surgeon, but also all assistants and nurses must be familiar with the steps in the operation before it is attempted. As a part of this preoperative preparation, it is advised that the publications of Nystrom, Meyer and Griswold be studied. In these articles may be found a summary of the recorded technique of this hazardous and spectacular surgical procedure.

To reduce the surgical risk as much as possible, the patient suspected of having pulmonary embolism should be transferred in bed to the operating room, where the final decision to operate should be made, and where a quick transfer of the patient to an operating table is possible. It is obvious that little time should be consumed in the local preparation of the operative field. This defect in surgical technique exposes those patients who survive the operation to wound infection which may involve the pericardium, mediastinum or pleura.

Technique of the Trendelenburg Operation with Modifications of Meyer and Nystrom (Figs. 275 to 280)

The operation can usually be completed without anesthesia. An anesthetist should be in readiness with positive pressure equipment to inflate the lung if the pleura is opened and to supply oxygen as needed.

The Trendelenburg T-shaped incision begins at the left sternal border and extends to the left along the second costal cartilage a distance of 10 cm. A second incision joining the sternal end of the first incision begins at the first costal cartilage and extends downward along the left sternal border to the fourth costal cartilage. The two triangular flaps outlined by these incisions are dissected free, to expose the left sternal margin and the second and third costal cartilages with the tips of the adjoining ribs.

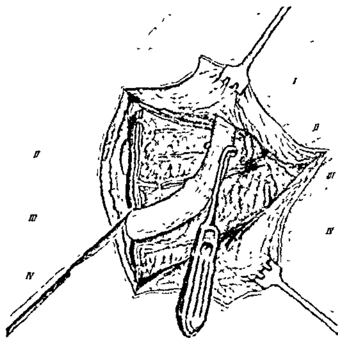


FIGURE 275. Trendelenburg operation for pulmonary embolism Technique of rib resection. (Meyer Surg , Gynec. & Obst., Vol. 50. By permission of Surgery, Gynecology and Obstetrics)

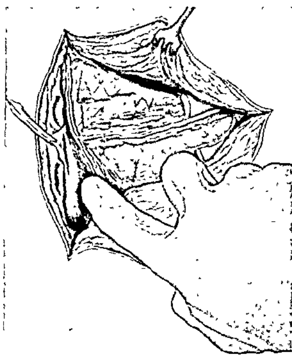


FIGURE 276 Trendelenburg operation for pulmonary embolism (*continued*). Dissection with forefinger of right hand beneath the insertion of the fourth rib (Meyer: Surg., Gynec & Obst, Vol. 50. By permission of Surgery, Gynecology and Obstetrics)

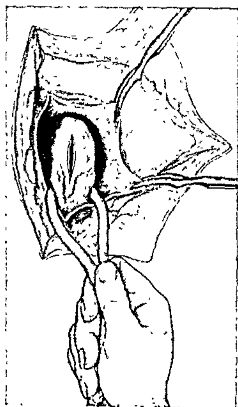


FIGURE 277. Trendelenburg operation for pulmonary embolism (*continued*). Rubber tube placed around the artery. (Meyer: Surg, Gynec. & Obst, Vol. 50 By permission of Surgery, Gynecology and Obstetrics)

Nystrom found the transverse portion of this incision unnecessary and obtains good exposure by a single incision extending along the *left* sternal margin from the upper edge of the second to the lower edge of the fourth costal cartilage.

About 8 cm. of the second and third costal cartilages and rib tips are quickly freed with a periosteal elevator and removed. A portion of the sternal margin may be clipped away with rongeurs to permit better exposure. The pleura and mammary vessels are exposed by retracting the intercostal muscles to the left. With finger dissection, the tissues beneath the inner end of the fourth costal cartilage and along the sternal margin can usually be freed and retracted outward. Injury to the pleura and

mammary vessels is carefully avoided. The mammary vessels may be clamped and ligated if necessary. A thin, moist saline pack will aid in protecting the retracted pleura. Through a thin layer of fat the pericardium is readily exposed by blunt dissection.

The pericardium is incised to expose the pulmonary artery. The lateral portion of the pericardial wall is clamped with Allis forceps and retracted to the left to increase exposure and to aid in protecting the pleura. The aorta and pulmonary artery are *identified; and with a specially designed probe a rubber tube* is passed through the pericardial sinus around the pulmonary artery. By pulling on the rubber tube, the vessel is constricted and hemorrhage controlled. An incision is made in the pulmonary artery, and both branches are explored for clots with special forceps. Since the clots are often friable, a suction tube may be used with greater success than forceps. The constriction should be momentarily released with the wound open to permit the washing out of clots from the heart. When exploring the artery, the wound should be temporarily closed with thumb and finger or with rubber-covered forceps so that the vessels may fill and prevent back pressure upon the heart. When the operator has assured himself that all the clot has been removed, the wound in the artery is clamped with rubber-covered clamps and closed with interrupted silk sutures. All oozing from the wound must be carefully controlled by adding sutures. The pericardium is closed with silk.

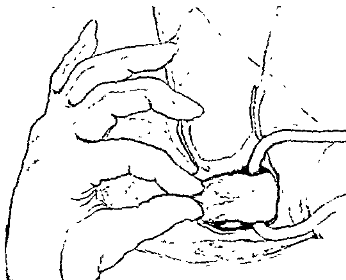


FIGURE 278. Trendelenburg operation for pulmonary embolism (*continued*) Incision in artery closed by grasping with thumb and forefinger (Meyer. Surg, Gynec. & Obst., Vol. 50. By permission of Surgery, Gynecology and Obstetrics.)

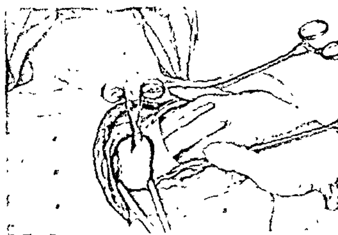


FIGURE 279 Trendelenburg operation for pulmonary embolism (*continued*) Exploration for emboli with clamp (Meyer Surg., Gynec & Obst, Vol 50. By permission of Surgery, Gynecology and Obstetrics)

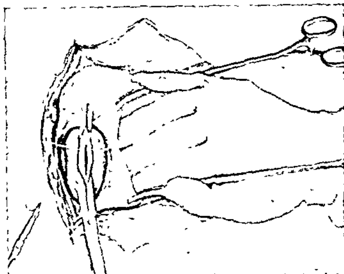


FIGURE 280. Trendelenburg operation for pulmonary embolism (*concluded*). Gauze-covered clamp applied. Method of placing sutures. (Meyer. Surg., Gynec. & Obst., Vol. 50 By permission of Surgery, Gynecology and Obstetrics.)

If the pleura has been opened, it should be repaired if possible. Positive pressure is indicated to expand the lung if there is much pneumothorax. Air may be aspirated from the pleural cavity after the wound is closed. The wound is sutured without drainage, using silk in the intercostal muscles and skin.

REMOVAL OF AORTIC SADDLE EMBOLUS

General Considerations

Arterial embolism is an emergency which requires prompt operation to prevent gangrene of an extremity. To restore circulation, the embolus must be removed within a few hours of the accident. Linton states that adherence to six principles is of greatest importance if an aortic embolectomy is to be successful. These principles are as follows: (1) Embolectomy must be done at the earliest possible time after lodgment of the embolus; (2) a direct and adequate exposure of the artery at the site of the embolus should be obtained; (3) the main artery distal to the embolus should be temporarily occluded before exposure of the artery at the site of embolism to minimize the danger of dislodgment of the embolus distalward in the arterial tree; (4) after opening the artery, the intima should not be traumatized; (5) complete control of the arterial inflow, both proximal and distal to the arteriotomy, is absolutely essential for the best results; and (6) the opening in the artery should be closed with scrupulous care with fine nonabsorbable sutures on an atraumatic needle.

Technique of Aortic Embolectomy (Fig. 281)

Spinal anesthesia is the choice. A right paramedian incision is made from about 6 cm. above the umbilicus almost to the pubis. The intestines are carefully displaced into the upper abdomen and held with moist gauze packs.

To expose the bifurcation of the aorta and the common iliacs, the peritoneum is incised in the midline and reflected to each side. The right common iliac is next freed just proximal to its bifurcation, and a clamp is applied. Linton prefers the Bethune clamp, but if this is not available, a rubber tube and clamp or tapes may be used. The left common iliac artery is also isolated and clamped distal to the embolus. By clamp-

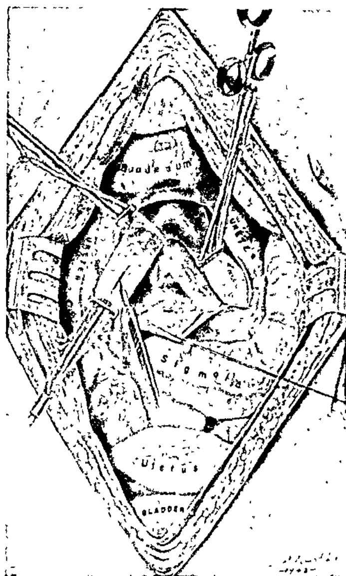


FIGURE 281 Technique of aortic embolectomy. The bifurcation of the aorta and iliac arteries have been exposed showing the location of the embolus. The Bethune clamps have been applied to the iliac vessels. (Linton: Surg., Gynec. & Obst., Vol. 80. By permission of Surgery, Gynecology and Obstetrics)

ing both iliac arteries, the embolus is prevented from escaping into the distal arteries. A third clamp is applied to the right iliac artery as near the aortic bifurcation as possible. This clamp is left open until immediately after removal of the embolus. The right iliac artery is carefully exposed, and an incision 1.0 to 1.5 cm. long is made through the vessel wall between the clamps. By manipulation of the bifurcation of the aorta and left iliac artery, the embolus will usually be extruded by arterial blood pressure. If there is evidence that not all the embolus is extruded, suction with a well lubricated catheter may be used to remove remaining particles. After the embolus is extruded the proximal clamp on the right iliac artery must be promptly closed to prevent serious hemorrhage. A flow of blood should be permitted to wash out any remaining particles of clot. The distal clamp of the right iliac artery is next opened, and free bleeding should occur if there are no emboli in the artery below and collateral circulation is good. The clamp on the left iliac artery is released, and the artery is tested for pulsation. If pulsation is absent, it is probable that another embolus has lodged at the iliac bifurcation and must be removed.

While the blood flow is controlled by the two clamps on the right iliac artery, the wound in the artery is closed with mattress sutures of silk. The edges of the wound are everted, placing intima to intima.

The clamps are removed, and the incision is reinforced with additional inter-

rupted sutures if necessary. The peritoneum is carefully closed to cover the field of operation. The abdominal incision is closed in layers. Heparin is administered for twenty-four hours following the operation.

LERICHE'S SYNDROME

General Considerations

Arteriosclerotic occlusive or thrombo-obliterative disease of the terminal aorta of a chronic progressive nature was first described as a clinical entity by Leriche in 1923. This syndrome, occurring most frequently in males in the fifth and sixth decades, is characterized by slowly progressive symptoms of arterial insufficiency of the lower extremities usually accompanied by bilateral absence of femoral pulsations. There is often pain or distress in the hips, thighs and back, and sexual impotence is also a noteworthy feature. The exact pathogenesis is somewhat obscure; however, it appears that the underlying pathologic process consists of arteriosclerosis beginning most frequently at or near the bifurcation of the aorta with atheromatous plaques and calcified, ulcerated areas of the intima leading to thrombus formation. This results in

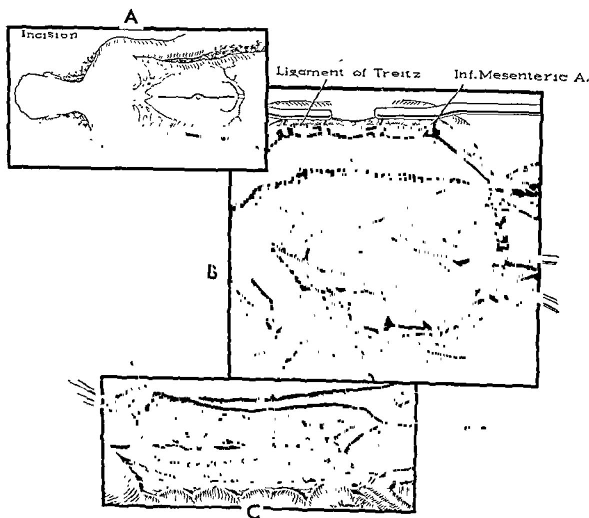


FIGURE 282. Resection of aortic bifurcation for occlusive disease and replacement with a homograft. *A*, Long midline incision. *B*, Incision through posterior layer of peritoneum and division of the ligament of Treitz to afford exposure of the involved area. *C*, Diseased terminal aorta exposed to the level of the left renal vein above and to the iliac bifurcations below. The inferior mesenteric artery has been ligated and divided (M. E. DeBakey, O. J. Creech and D. A. Cooley: Ann. Surg., Vol. 140)

a progressive stenosis of the lumen ultimately resulting in complete occlusion. The diagnosis can be established and the extent of the disease determined by lumbar aortography. Earlier, surgical treatment consisted in lumbar sympathectomy combined with excision of the involved area to prevent progression of the disease. Later, certain cases were managed by thromboendarterectomy. During recent years the treatment of choice has consisted in removal of the involved segment and replacement with an aortic homograft or prosthesis.

Technique of Operation (DeBakey) (Figs. 282, 283)

The abdomen is opened, using a long midline incision. The bowel is packed off, and the posterior peritoneum is opened over the aorta from the division of the common iliacs to the area above the renal arteries. It is usually necessary to divide the ligament of Treitz above and to expose the left renal vein as it passes over the aorta.

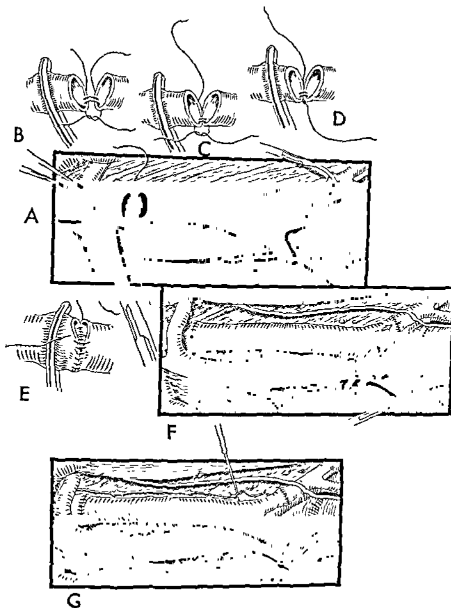


FIGURE 283. Resection of aortic bifurcation for occlusive disease and replacement with a homograft After removal of the diseased segment of the aorta, continuity is re-established by use of an aortic homograft. *A* through *E*, The anastomosis is made with a continuous over-and-over suture of fine arterial silk *F*, When the aortic and left iliac anastomoses have been completed, occluding clamps to these vessels are loosened, permitting flow through the left iliac vessels while the right iliac anastomosis is being performed. *G*, *Bilateral lumbar sympathectomy is done after completion of the anastomoses.* (M. E. DeBakey, O. J. Creech and D A Cooley: Ann. Surg, Vol. 140)

In most instances it is necessary to ligate and divide the inferior mesenteric artery at its origin. Occluding clamps are applied to the aorta just below the renal arteries and to the common iliac arteries at their bifurcation. The diseased segment of aorta is then removed, taking care to ligate the lumbar branches carefully. It may be necessary to remove thrombi and atheromatous debris remaining in the proximal and distal segments. If the process has extended beyond the iliac bifurcation, it may be necessary to replace additional distal segments with a graft. Continuity is then re-established by inserting a suitable aortic homograft or prosthesis. The proximal anastomosis is made first, using a simple over-and-over suture of 0000 arterial silk. The left iliac anastomosis is next performed and the occluding clamps removed, permitting blood flow through the graft into the left lower extremity. The right lower anastomosis is then completed, using a simple over-and-over stitch. After the graft has been inserted, bilateral lumbar sympathectomy is performed. The abdominal wound is then closed in layers.

ARTERIAL BY-PASS PROCEDURE

General Considerations

Arterial insufficiency of the lower extremity may result from segmental arteriosclerotic lesions, often in the superficial femoral artery. When this is the case, the

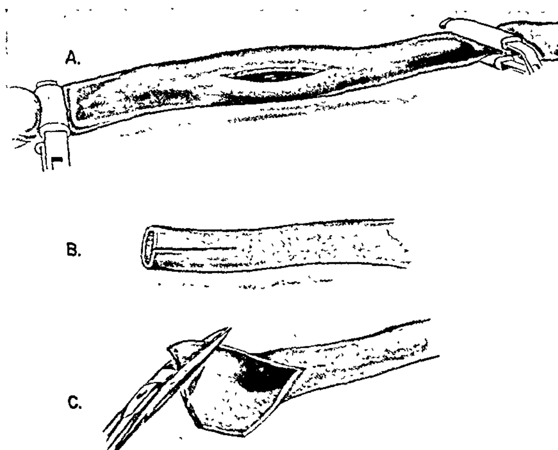


FIGURE 284. Arterial by-pass procedure showing details of the end-to-side anastomosis. *A*, After isolation of the host artery a longitudinal incision is made approximately 3 times the length of the diameter of the graft *B*, A longitudinal incision approximately the same length as the incision of the host artery is then made in the end of the graft. *C*, The corners are cut away. (R. Linton: Surgery, Vol. 38.)

blood supply of the extremity frequently can be benefited if the vessel is relatively normal above and below the area of obstruction. It may be possible to remove the obstruction by opening the vessel and removing the thrombus and arteriosclerotic plaques directly, or by excising the segment and replacing it with a homograft or prosthesis. However, in many instances the most satisfactory approach has been the *insertion of a homograft or prosthesis above and below the obstructing area to by-pass the obstruction.* Numerous variations of this technique are used, depending upon the length and area of obstruction. In general, arterial homografts have been more satisfactory than have the synthetic prostheses. Before operation the extent and nature of the diseased area must be carefully determined by use of arteriography.

Technique of Operation (Figs. 284, 285, 286)

Two small incisions are made, one above and the other below the obstruction, placed at the proper levels to expose relatively normal segments of the artery as determined by the arteriogram. *The two incisions are connected* by a *tunnel* made by blunt dissection, using a vein stripper or ring forceps. The artery is exposed above and

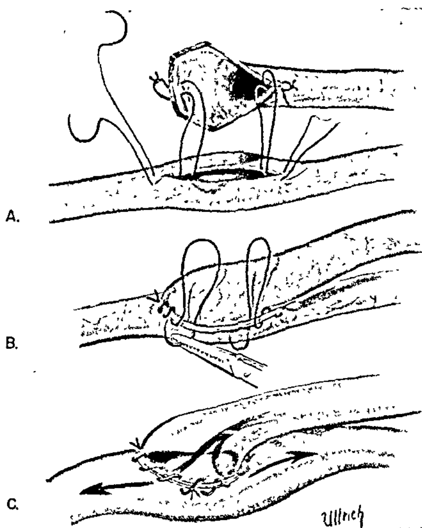


FIGURE 285 Arterial by-pass procedure showing details of the end-to-side anastomosis (*concluded*). *A*, Two strands of fine arterial silk are tied together and used to approximate the ends of the anastomosis. *B*, [illegible]
Wh[illegible]
vessels involved (*C*) (R Linton. Surgery, Vol 38)

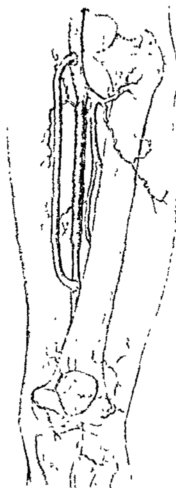


FIGURE 286. Arterial by-pass procedure illustrating by-pass of a diseased segment of the femoral artery by the use of a homograft anastomosed by the end-to-side technique. This procedure does not interfere with any collateral circulation which may have developed.

below, and is then occluded above in an atraumatic fashion. An incision is then made in the artery in the long axis of the vessel, and the end of the graft is anastomosed to this opening in an end-to-side fashion, using a continuous running suture of 5–0 silk. After the anastomosis has been completed the free end of the graft is drawn through the previously constructed tunnel, and a similar anastomosis is made in an end-to-side fashion to the artery beyond the area of obstruction.

Linton has described a technique of doing end-to-side anastomosis in which the lumen of the anastomosis is considerably larger than the lumen of the individual vessels. The incision in the artery is made approximately three times as long as the diameter of the graft. An incision is then made in the end of the graft approximately the length of the incision previously made into the artery and resultant corners of the arterial flap cut away. Stay sutures are then placed at each end of the proposed anastomosis, using 5-0 arterial silk, and the anastomosis completed with an over-and-over suture as illustrated. The clamps are released, and any bleeding through the suture holes usually is controllable by gauze pressure. Occasionally an extra suture is required in the anastomotic line. The incisions are then closed.

THROMBOENDARTERECTOMY

General Considerations

In certain instances, particularly when the area of peripheral vascular obstruction is short, circulation to the extremity may be increased by opening the diseased

artery and removing the obstructing thrombus and arteriosclerotic debris. This procedure has an advantage in that no graft is necessary. However, the tendency to reformation of thrombus is great, and, in addition, collateral circulation may be further damaged during the operating procedure.

Technique of Thromboendarterectomy (Cannon and Barker) (Figs. 287, 288)

When the obstructing segment is short as determined by aortography, an incision is made over the involved area and the artery exposed. The artery is occluded in an atraumatic manner above and below the obstruction and a longitudinal incision made over the entire extent of the obstruction. The obstructing intimal segment and thrombus are removed and the longitudinal incision closed by a running over-and-over suture of 5-0 atraumatic arterial silk. The denuded arterial surface is flushed with dilute heparin solution before closure.

When the obstructing segment is long, the procedure is done by the following technique: spinal anesthesia is preferred. The patient is placed supine on the operating table and the entire surface of the extremity prepared from above the groin to the toes. A preliminary incision is first made on the medial aspect of the thigh paralleling the sartorious muscle, beginning just above the knee joint and extending proximally a distance of about 8 cm. This permits exposure of the popliteal artery, which can then be explored for collapsability. In addition, an arteriogram of the lower leg beyond the popliteal can be performed to determine the status of the vessels of the lower leg. A 3-cm. longitudinal incision can then be made in the upper portion of the popliteal artery and a fine polyethylene catheter inserted into the distal artery and secured with a Penrose drain clamped around the artery. A dilute solution of heparin is then injected into the distal arterial tree to prevent clotting during the remainder of the operation. The vessel can then be exposed above the area of obstruction, usually in the region where the common femoral divides, and occluded. A slanting, beveled

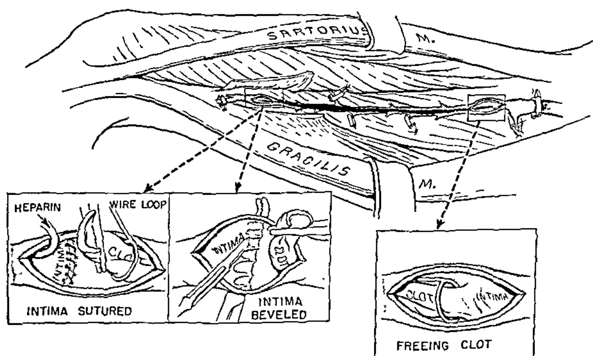


FIGURE 287. Thromboendarterectomy. Longitudinal openings are made in the vessel above and below the obstruction. The intima is incised in a beveled fashion and stripped with a fine wire stripper from below upward. (J. Cannon and W. F. Barker. Surgery, Vol. 38.)

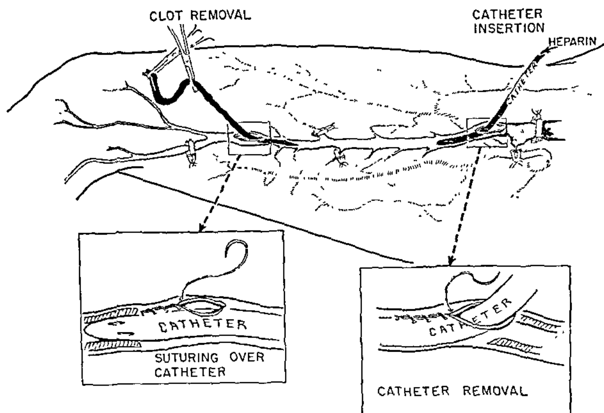


FIGURE 288. Thromboendarterectomy (*concluded*). The longitudinal openings in the artery are closed with a simple over-and-over continuous suture of fine atraumatic arterial silk. This may be facilitated by using a catheter as a stent, as illustrated (J. Cannon and W. F. Barker: Surgery, Vol. 38.)

incision is made in the intima at the distal opening in the vessel as illustrated, and if necessary the distal cut edge of the intima carefully tacked to the arterial wall with fine silk to prevent subsequent dissection of the distal intimal edge. The proximal end of the intima which has been dissected free is then fitted inside the loop of a fine wire stripper and the cleavage plane between the intima and media developed up the artery as far as the stripper will pass without undue pressure. If obstruction is met, the artery is again exposed and opened in the area of obstruction and dissection continued from that area as previously described. Removal of the entire length of obstructing intima is then possible. The entire area is flushed with dilute heparin and the openings in the artery closed with fine over-and-over continuous silk.

The occluding clamps on the popliteal, deep femoral and common femoral arteries are then released in that order. The incisions are checked carefully for hemostasis and then closed with fine interrupted sutures. Heparin is given parenterally to cause the clotting time to be slightly elevated and continued until the pedal pulse is returned. Movement of the extremity is encouraged, but ambulation is usually *not* permitted before the fifth postoperative day.

OPERATIONS FOR ANEURYSM

General Considerations

Various methods of arterial ligation for the cure of aneurysm have been used, beginning with the operation of Antyllus in the second century of the Christian era (Fig. 289). While these operations may be useful in selected cases, direct attack upon

an aneurysm that can be exposed for the purpose of complete extirpation, obliteration or removal is desirable. The revolutionary work of Matas did much to standardize the treatment of aneurysms. However, his methods of obliterative, restorative and reconstructive endoaneurysmorrhaphy are applicable only to aneurysms of the smaller vessels. As methods for obtaining and preserving arterial homografts were perfected, and with the development of the various cloth prostheses, complete excision of aneurysms of the thoracic and the abdominal aorta as well as smaller vessels with the re-establishment of vascular continuity by homograft or prosthesis became feasible. The pioneer work of Dubost, DeBakey and Cooley, Bahnson and others in this field altered the outlook in cases of aneurysm of the thoracic and abdominal aorta from one of hopelessness to a generally favorable prognosis. The wrapping of aneurysms with fibrogenic materials such as cellophane, as well as the various methods of wiring of aneurysms as developed by Matas, Blakemore, Moore-Corradi and others, generally has been abandoned.

Before operation for aneurysm the size and extent of involvement can often be determined with accuracy by the use of aortography.

The comments of Halsted concerning errors in the treatment of aneurysms are still applicable: "Common errors in the treatment of aneurysms are the following: (1) Opening the sac of a pulsating hematoma without first making a temporary occlusion

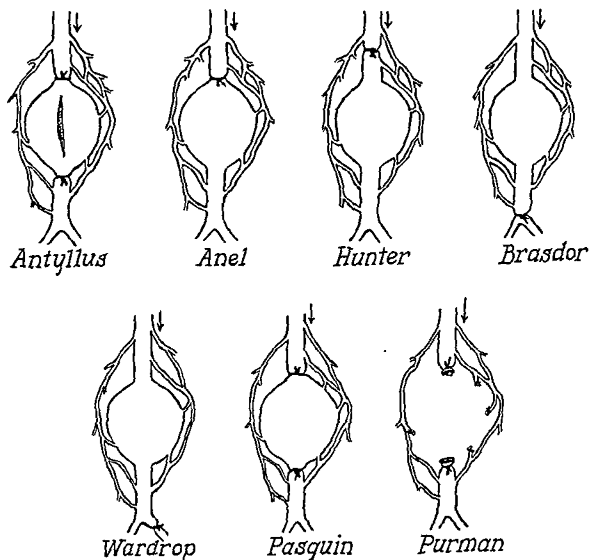


FIGURE 289. Various methods of ligation of aneurysms. (After Keen.)

of all the possible sources of hemorrhage; (2) permanent ligation of a great arterial trunk as a precautionary measure in the search for a distal bleeding point; (3) ligation of a trunk too far from the aneurysm; (4) stuffing the wound with gauze to arrest hemorrhage; (5) drainage; (6) the employment of catgut for ligature, or of silk that is too fine; (7) ligation of the artery proximal to an arteriovenous aneurysm or fistula."

Large aneuryms are generally in close proximity to major nerves, which may be injured by cutting or ligation. Careful and painstaking anatomical dissection is necessary in exposing an aneurysm, which may assume many bizarre shapes and distort the normal anatomy to an extreme degree.

The hazards of operations for aneurysms are greatly reduced by proper incisions and exposure. Elkin emphasized that adequate exposure with isolation and control of vessels is usually of more technical importance than surgical attack on the lesion itself.

In the neck, transverse incisions heal with less scarring than vertical incisions. Vessels in the cubital and popliteal spaces should be exposed by S-shaped or Z-shaped incisions. At the base of the neck a portion of the clavicle may be removed for adequate exposure. Subperiosteal resection of a portion of the clavicle does not interfere with motion and does not produce any noticeable deformity. A portion of the clavicle, sternum and first and second ribs may be resected to expose aneurysms in the upper thorax. In exposing the anterior tibial, posterior tibial and peroneal vessels, the upper portion of the fibula may be removed without disturbing the functions of the knee joint. Incisions through the sole of the foot should be avoided. An incision in the medial side of the foot will usually give adequate exposure of the plantar vessels.

Before operation, provision for adequate blood replacement is essential. Anesthesia may be a special problem, depending upon the location of the aneurysm. When cross-clamping of the aorta above the level of the renal arteries is required for a protracted period of time, the use of hypothermia may be of value in the prevention of complications due to prolonged ischemia below the level of clamping. In other instances the use of temporary shunts of various types around the area of clamping is necessary.

Technique of Aneurysmorrhaphy (Matas)

Aneurysm of the smaller arteries may be managed by aneurysmorrhaphy with excellent results. In many instances lumbar sympathectomy is advisable to ensure maximal peripheral circulation. Many of these operations may be done successfully with local anesthesia. Spinal or gas anesthesia is satisfactory in other cases. Before exposing the sac, the circulation must be controlled by tourniquet or exposure and compression of the artery proximal to the sac. Two incisions may be necessary in some cases, but usually the artery can be freed above the aneurysm and the aneurysm exposed through the same incision. The artery may be compressed by ligature, rubber-shod clamp, or tape and traction.

Obliterative Endoaneurysmorrhaphy (Fig. 290). The sac is incised and emptied without disturbing its surroundings. The openings of all vessels leading to or from the sac, including those of the main vessel, are carefully closed with silk or fine chromic catgut sutures. The cavity is obliterated by multiple rows of sutures. A portion of the sac wall may be excised if it can be done without disturbing the surrounding tissues. The overlying fascia and skin are closed without drainage.

Restorative Endoaneurysmorrhaphy (Fig. 290). This operation is applicable to aneu-

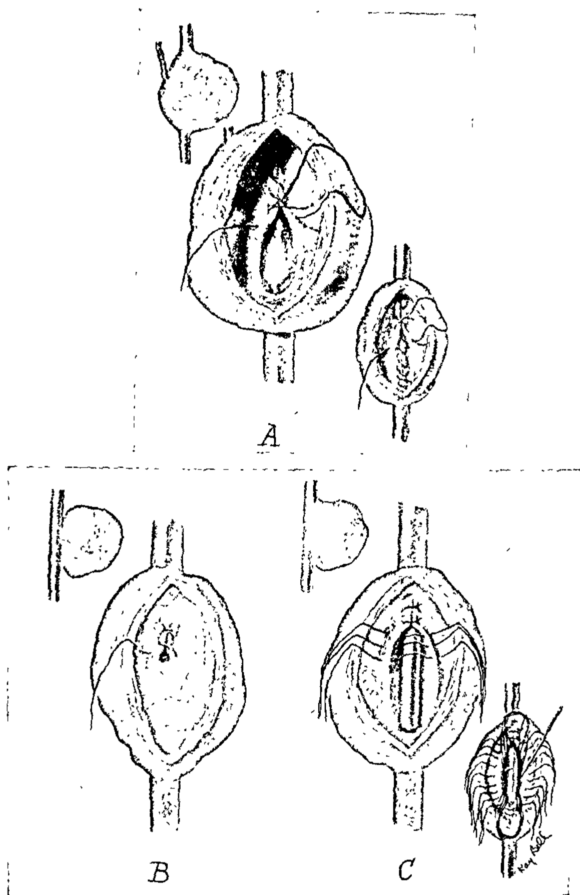


FIGURE 290. *A*, Obliterative endoaneurysmorrhaphy *B*, Restorative endoaneurysmorrhaphy *C*, Reconstructive endoaneurysmorrhaphy. (Matas)

rysms of the sacciform type having a small opening into the parent vessel and without distortion of the normal outline of the artery. The sac is freed of all clots and the opening closed with interrupted sutures which penetrate all the coats of the sac. The sutures must be placed so that there is no encroachment upon the lumen of the artery. The sac is obliterated as above by multiple sutures which approximate the endothelial surfaces.

Reconstructive Endoaneurysmorrhaphy (*Fig. 290*). This operation is suitable for aneurysms of the fusiform type with firm elastic walls and in which the openings of the main artery lie on the same level in close proximity at the bottom of the sac. The parent artery is reconstructed by suturing the walls of the sac over a catheter or rubber tube to restore the channel. Before the last suture is tied, the tube is removed from the channel. The sac is obliterated as described in the foregoing procedures.

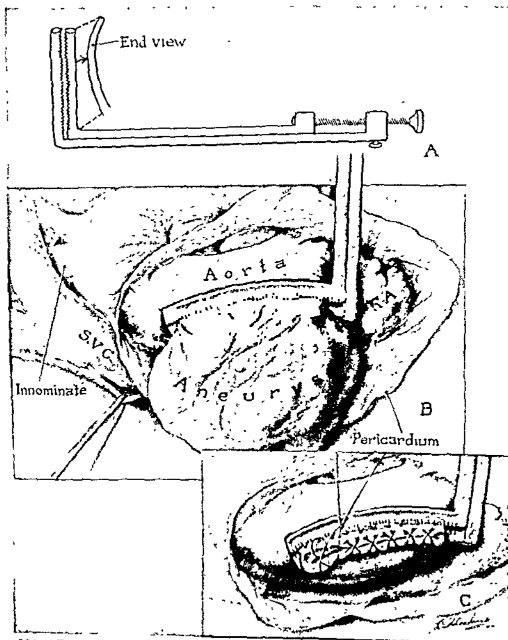


FIGURE 291. Excision of saccular aneurysm of ascending aorta, showing occlusion of the mouth of the aneurysm by means of a special clamp and closure of the mouth of the aneurysm after excision of the sac with multiple interrupted sutures of 0000 arterial silk. (H. Bahnson: Henry Ford Hospital International Symposium on Cardiovascular Surgery.)



FIGURE 292. Closure of saccular aneurysm of the aortic arch by endoaneurysmorrhaphy. After the aorta has been isolated and cross-clamped above and below the aneurysm the mouth of the sac is sutured and reinforced with portions of the adjacent aneurysmal sac. (H. Bahnson: Henry Ford Hospital International Symposium on Cardiovascular Surgery.)

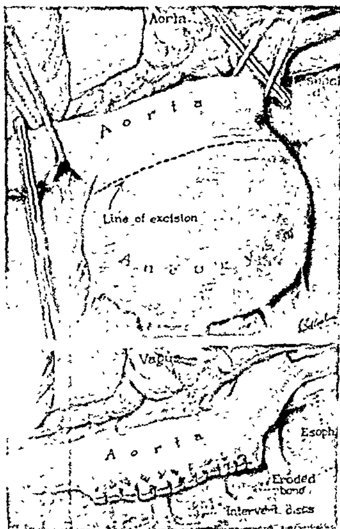


FIGURE 293. Excision of saccular aneurysm of the descending aorta by lateral aortorrhaphy. The aorta is isolated and occluded above and below the lesion, after which the aneurysm is dissected and amputated at a wide mouth The mouth of the excised aneurysm is then closed with multiple interrupted sutures and the clamps removed (H. Bahnson Henry Ford Hospital International Symposium on Cardiovascular Surgery.)

Excision of Saccular Aneurysm (Bahnson) (Figs. 291, 292, 293)

Many aneurysms of the thoracic aorta are saccular, presenting a localized blowout with a relatively small neck. These aneurysms, usually syphilitic, traumatic, mycotic or congenital, lend themselves to excision with closure of the neck of the sac. These may also be repaired by a restorative endoaneurysmorrhaphy (Fig. 292) or by lateral aortorrhaphy (Fig. 293). It is imperative that the dissection first be carried out in areas which are relatively uninvolved, and only after the adjacent aorta and mouth of the aneurysms have been isolated should dissection about the aneurysm itself be performed.

Fusiform Aneurysms

General Considerations. Arterial aneurysms due to arteriosclerosis are generally fusiform in type and in general are not suitable for endoaneurysmorrhaphy or lateral aortorrhaphy, as are saccular aneurysms. This type of aneurysm may occur in the peripheral vessels, but offers the greatest problem when occurring in the abdominal aorta. Before 1951 surgical management of this type of aortic aneurysm consisted in attempts to produce fibrosis around the aneurysm by wrapping with material such as cellophane and the wiring techniques. In 1951 Dubost successfully excised an aneurysm of the abdominal aorta and re-established continuity with a homograft. Since that time DeBakey and Cooley as well as other authors have operated successfully on large series of such patients, using either aortic homografts or one of the various synthetic cloth prostheses to re-establish vascular continuity. As pointed out by DeBakey and Cooley, these lesions characteristically occur in that segment of the aorta distal to the origin of the renal arteries so that aortography is usually not necessary before operation. These authors as well as others have operated successfully on a large number of patients having abdominal aneurysms as planned procedures, but also several cases have been managed successfully as emergency procedures following rupture of the aneurysm. It is their opinion that the diagnosis of an abdominal aneurysm of the aorta is in itself sufficient indication for operation, and that the aneurysm itself provides a greater risk to the patient than the risk of operation even in the face of serious cardiovascular, renal or respiratory disease as well as advanced age. In most instances it is necessary to excise the aortic bifurcation and a portion of the common iliac vessels as well, and in certain cases the lesion may extend beyond the common iliacs, requiring further excision and grafting below that area.

Technique of Excision and Grafting (Dubost) (Figs. 294 to 298). A long midline incision is made from a few centimeters below the xiphoid process to just above the pubis. The small intestine is packed out of the field, or it may be delivered from the peritoneal cavity entirely to obtain liberal exposure. The peritoneum over the root of the mesentery is incised and the aneurysm exposed posteriorly. The aorta proximal to the aneurysm is mobilized and encircled with a piece of umbilical tape. Care must be taken to avoid injury to the left renal vein. The iliac arteries distal to the aneurysm are similarly mobilized and encircled with umbilical tape. Since the inferior mesenteric artery usually has its origin from the aneurysm, this vessel is mobilized, ligated and divided. The aorta above and the iliacs below the aneurysm are clamped with arterial clamps. The involved segment can then be clamped near the aneurysm and divided. Dissection of the aneurysm may then be carried out either from above down-

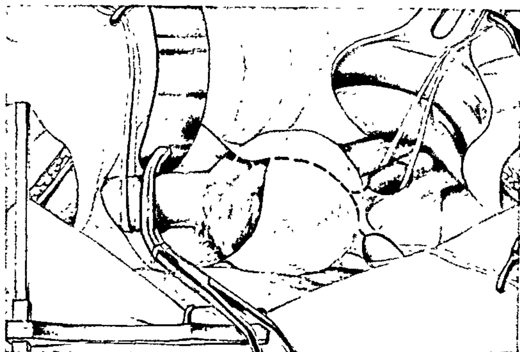


FIGURE 294. Abdominal aortic aneurysm The aorta above and the iliacs below are first isolated and secured by umbilical tapes, after the peritoneum over the aneurysm has been incised. The aorta is occluded above by a suitable atraumatic clamp. (C. Dubost: Henry Ford Hospital International Symposium on Cardiovascular Surgery.)

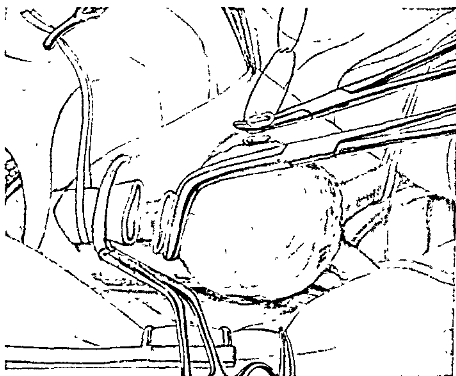


FIGURE 295 Abdominal aortic aneurysm (*continued*). The inferior mesenteric artery has been ligated and divided The aorta just proximal to the aneurysm has been doubly clamped and divided to facilitate dissection of the aneurysmal sac posteriorly. Care must be taken to isolate and clamp the lumbar arteries and to avoid injury to the adjacent vena cava, which is often closely adherent to the aneurysmal sac (C. Dubost Henry Ford Hospital International Symposium on Cardiovascular Surgery.)

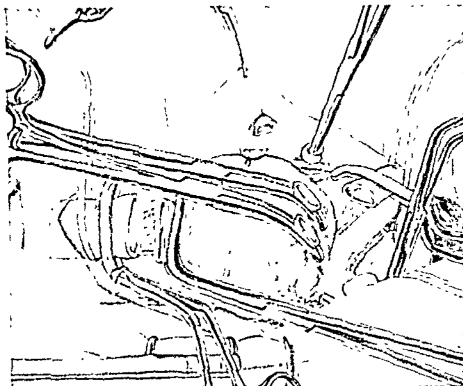


FIGURE 296 Abdominal aortic aneurysm (*continued*). The iliac arteries have been doubly clamped and divided to permit dissection of the aneurysm from below upward (C Dubost: Henry Ford Hospital International Symposium on Cardiovascular Surgery.)

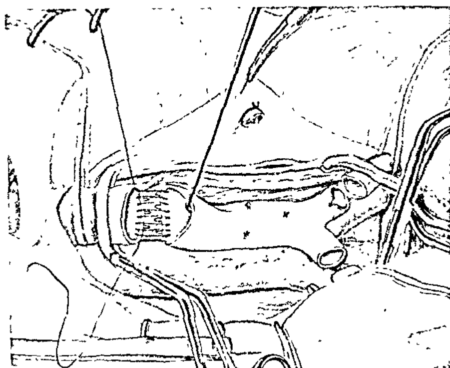


FIGURE 297. Abdominal aortic aneurysm (*concluded*). The aneurysm has been excised, and a homograft is being inserted The upper anastomosis is completed first, using an everting mattress suture, as here illustrated, or a simple over-and-over continuous suture of atraumatic arterial silk. (C. Dubost: Henry Ford Hospital International Symposium on Cardiovascular Surgery.)

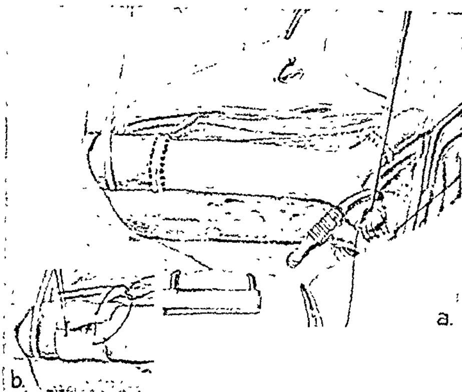


FIGURE 298 *a,* The upper anastomosis and left iliac anastomosis have been completed and the clamps removed to permit blood flow through this area. The right iliac anastomosis is being completed. *b,* A free arterial graft is placed around the upper anastomosis for reinforcement when the wall is in poor condition (C. Dubost: Henry Ford Hospital International Symposium on Cardiovascular Surgery.)

ward or from below upward or both, depending upon the ease of excision. The involved lumbar arteries are clamped, ligated and divided as they are encountered.

Care must be taken in excising the aneurysm from the adjacent vena cava, and if the aneurysm is tightly adherent to the cava, that portion of the aneurysmal sac which is adherent to the vein is left in place rather than risking serious injury to the vena cava. When the aneurysmal sac has been excised, a suitable replacement, either of arterial homograft or cloth prosthesis, is chosen and the upper anastomosis between the graft and aorta made first, using a simple over-and-over suture of 0000 arterial silk. The aorta above may be diseased and partially dilated, creating difficulties in obtaining a satisfactory anastomosis. Anastomosis of the graft distally to the left common iliac is then done in a similar fashion, after which the clamps may be released from all but the right iliac portion of the graft to allow blood to flow through the left extremity. The remaining limb of the graft is then anastomosed to the right iliac artery in similar fashion. After release of the clamps there may be temporary bleeding around the anastomosis site; this can be controlled by pressure or, if necessary, additional stitches. The peritoneum is then sutured over the graft and the abdominal incision closed in layers.

OPERATIONS UPON ARTERIOVENOUS ANEURYSMS

General Considerations

The term "arteriovenous ane[illegible] ow generally [illegible] to all abnormal communications between large a[illegible] T[illegible] different types

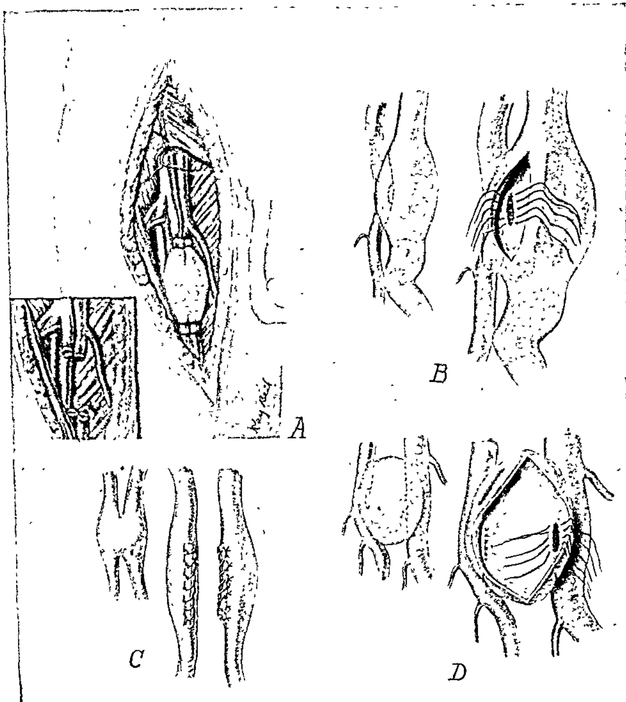


FIGURE 299. Treatment of arteriovenous aneurysm. *A*, Quadruple ligation of vessels proximal and distal to aneurysm and complete excision of aneurysm *B*, Aneurysmal-varix type of arteriovenous aneurysm. The vein is incised, and the artery is closed with interrupted silk sutures (Bickham). *C*, Division of aneurysm and closure of artery and vein. *D*, Varicose-aneurysmal sac is incised, and the openings in the artery and vein are closed with interrupted silk sutures. Wall of the sac is sutured over the sites of the openings in the artery and vein (Bickham)

(Fig. 299). They are usually the result of trauma, although they may be congenital. Reid and Andrus believe that cirsoid aneurysms should be included in this group, since they conclude that there is no difference between this type and other arteriovenous aneurysms except that in the former the abnormal communications occur between smaller vessels. They are also of the opinion that abnormal communications are to be found between small arteries and veins in arterial angiomas.

Dangers and Safeguards

Because of serious circulatory disturbances which may result in hypertrophy and dilatation of the heart with ultimate death, operation is indicated for arteriovenous aneurysms of the larger vessels to restore circulatory balance. Nonoperative treatment has not been successful, although spontaneous cure may rarely result with careful rest.

There has been some difference of opinion concerning the proper *time for operation*, but it is generally agreed that operation should be delayed after arteriovenous aneurysms due to injury for three to six months unless progressive cardiac hypertrophy necessitates earlier intervention. Reid and Andrus have given the following reasons for *delayed* operation:

(1) A good collateral circulation develops which permits excision of the fistula without fear of gangrene. (2) The vessels injured become thoroughly healed and thus their dissection becomes easier and safer, especially when a tourniquet cannot be used. (3) Infection of the wound is less likely after the hematoma becomes absorbed and the tissues return to normal. (4) The initial loss of blood at the time of injury becomes fully restored. (5) Some of the cases will heal spontaneously during the first six months, especially if the patient and part are put at rest. (6) The evil effects of some arteriovenous aneurysms, particularly those in the upper extremities, may become so mild as not to justify any operative treatment.

Ligation of the artery proximal to an arteriovenous aneurysm is not a proper treatment except in such intracranial lesions. It does not cure the condition and frequently results in gangrene. Combined proximal and distal ligations of the artery are also not satisfactory. Quadruple ligation, or ligation of the artery and vein both above and below the aneurysm, may be successful. This method may fail if all branches of both artery and vein in the segment involved are not securely ligated. In cases of recent injury, restoration of the continuity of both vessels by end-to-end or lateral suture will give good results, or if this is not possible, an arterial homograft, a vein graft or synthetic prosthesis may be used to bridge the defect in the artery. In old cases the pathologic changes in the vessels and surrounding structures make restoration by anastomotic suture difficult or impossible because of the discrepancy in size between the proximal and distal arteries. Quadruple ligation near the aneurysm, with complete excision of the fistula-bearing portion, yields excellent results in the old cases which have developed a good collateral circulation. The Matas technique of obliterative or restorative endoaneurysmorrhaphy may be applied to arteriovenous aneurysms with success in selected cases. Excision of the fistula or sac between the vessels with lateral suture is a satisfactory operation when technically possible.

Technique of Quadruple Ligation

An incision 8 to 10 cm. long is usually necessary to obtain adequate exposure. A tourniquet is used when possible. If a tourniquet cannot be used, the artery and vein should be exposed first above the fistula, either through the same or another incision, and the vessels constricted by tension tapes or rubber-shod clamps. The entire sac or communicating fistula with the artery and vein, both above and below, should be carefully freed before attempting ligation. Each vessel should then be ligated close to the fistula with double ligatures of medium heavy silk. To avoid recurrence, collateral

vessels entering the sac or vessels between the major ligatures should be freed and ligated. If ligation of collateral branches is not practical, the aneurysm may be obliterated by heavy ligatures or by sutures through the sac. The dangers involved are hemorrhage, infection, injury to nerves and damage to collateral vessels.

Technique of Quadruple Ligation with Excision of Aneurysm (Fig. 299)

This procedure is the same as the technique of quadruple ligation up to the point of excision. Both vein and artery with the fistula are completely excised between the double ligatures placed above and below. Exact hemostasis is important.

Technique of Endoaneurysmorrhaphy (Matas-Bickham) (Fig. 299)

Circulation in both artery and vein is controlled by tourniquet or temporary pressure applied to the vessels above and below the aneurysm. The sac is freed and opened wide to expose its entire interior. The openings into the artery and vein are closed with interrupted silk sutures. The sac may then be partially or completely obliterated or a portion excised as indicated in the individual case. Collateral circulation should not be much disturbed by this operation.

Technique of Endoaneurysmorrhaphy for the Aneurysmal-Varix Type of Arteriovenous Aneurysm with Preservation of the Sac (Fig. 299)

The sac and major vessels are exposed and circulation controlled as described above. An incision is made in the dilated vein opposite the fistula of sufficient length to permit proper exposure for suture. The opening between the vessels is closed with interrupted silk sutures. This row of sutures should be reinforced with a continuous Lembert suture. To avoid the possibility of embolism, as little suture material as possible should be left exposed within the vein. The incision in the vein may be closed with interrupted mattress sutures of silk, placing intima to intima. This row of sutures should be reinforced with a continuous or interrupted suture through the cut edges of the vein.

Technique of Excision of Sac or Fistula with Suture of Artery and Vein (Fig. 299)

After exposure of the aneurysm and control of circulation, the sac or communication between the vessels may be completely excised and the openings in the artery and vein sutured. Interrupted mattress sutures of silk approximating the intima should be used. This row of sutures should be reinforced by a second row of interrupted or continuous sutures placed along the cut edges in the vessels. This technique may be modified to suit the case. Mason describes an operation in which the subclavian vein was excised and the opening in the subclavian artery closed and reinforced by a portion of the venous sac.

OPERATION FOR CIRSOID ANEURYSM

General Considerations

Reid and Andrus believe that cirsoid aneurysms and arterial angiomas are the result of abnormal arteriovenous communications and should not be classified as tumors. They will disappear if there is complete obliteration of abnormal anastomoses.

Proximal ligation of the main artery and surrounding vessels may result in improvement, but will seldom cure. The treatment of choice is excision. Injections of astringent solutions or boiling water, electropuncture, and application of caustics have met with some success, but are not generally recommended. Radium and x-ray may be used in selected cases. The lesion sometimes reaches the stage of inoperability, and, if in an *extremity, amputation may be advisable.*

Dangers and Safeguards

The greatest danger accompanying operation is *hemorrhage.* Location of the abnormal communication or communications is a common difficulty. In some cases it is much safer to do the operation in stages. Blood for transfusion should always be in readiness.

Technique of Operation for Cirsoid Aneurysm of the Scalp (Fig. 300)

A general anesthetic is usually necessary. Through short separate incisions, pulsating vessels leading to the aneurysmal mass are ligated and divided. These *ligations usually include the superficial temporal artery and vein, occipital artery* and vein, and the supraorbital artery and frontal vein. A continuous locked suture is placed through the scalp around the aneurysm to control bleeding. A semicircular incision is made within the encircling hemostatic suture and a flap of scalp reflected

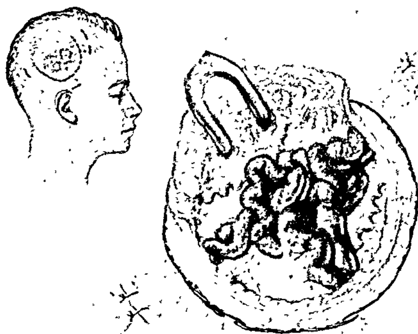


FIGURE 300 Technique of excision of a cirsoid aneurysm of the scalp Pulsating vessels leading to the aneurysmal mass are ligated through small incisions These ligations usually include the superficial temporal artery and vein, occipital artery and vein and the supraorbital artery and frontal vein A continuous lockstitch suture is placed about the aneurysm to control bleeding A flap of the scalp is reflected and the aneurysm is excised. All bleeding vessels are carefully ligated as the dissection proceeds and after the lockstitch hemostatic suture is removed. (Redrawn from Pemberton· Arch Surg)

to expose the aneurysm. The mass of dilated vessels is excised. All open vessels are carefully ligated or caught in sutures. The hemostatic suture is cut and removed a section at a time so that all bleeding points may be carefully controlled. The scalp wound is closed and a pressure dressing applied.

OPERATIONS UPON THE HEART AND PERICARDIUM

General Considerations

The successful obliteration of a patent ductus arteriosus by Gross in 1938 marked the beginning of a new era in the surgery of the heart and great vessels. Although considerable investigative work had been done and isolated operative procedures had been carried out, including attempts to dilate a stenosed mitral valve before that date, Gross' work formed the opening wedge in the surgical attack on congenital cardiovascular disease with subsequent application to the surgical management of inflammatory and degenerative diseases of the heart and great vessels. Since that time new operative techniques have been devised and new mechanical aids developed until at last it is possible to shunt the blood flow away from the heart by means of artificial heart-lung machines, thus permitting operative procedures to be carried out within the chambers of the heart in a relatively bloodless field. Progress has been so rapid in this field that many procedures thought to be well standardized have been superseded by newer and better methods, and indeed it is anticipated that future developments may well superannuate some of the procedures used widely today.

RESUSCITATION OF THE HEART

The sudden, unexpected cessation of cardiac function during operation, during the preoperative or postoperative period or occasionally following trauma is known as cardiac arrest. Under this category should not be included such things as uncontrollable shock, massive blood loss or cardiovascular accidents which may occur during operation. Cardiac arrest may be of two types; (1) cardiac standstill and (2) ventricular fibrillation. These occur in approximately the ratio of ten to one. It is estimated that cardiac arrest occurs in approximately one of 3000 to 4000 operations. The incidence is considerably higher in operations carried out on the heart itself or on the lungs with an open thorax.

Although such factors as pain stimuli, vagovagal reflexes, blood loss and displacement and manipulation of the heart are contributing factors, by far the most important cause of cardiac arrest is inadequate pulmonary ventilation. Inadequate pulmonary ventilation results not only in hypoxia, but also the retention of carbon dioxide. Both these factors are thought to contribute greatly to the development of cardiac standstill or ventricular fibrillation. It is obvious, therefore, that the most important aspect of cardiac arrest is preventative. By ensuring adequate pulmonary ventilation at all times the incidence of cardiac arrest will be minimized.

During open thoracic procedures when the heart can be observed directly the recognition of cardiac arrest is simple. When such is not the case, the most reliable sign is the absence of a pulse. This can be determined by the anesthesiologist or, if the

abdomen is open, by the surgeon upon palpation of the aorta. The absence of heart sounds on auscultation and the absence of blood pressure are confirmatory. Electrocardiography is helpful, but may not be available when such an emergency arises.

The treatment of cardiac arrest must be carried out promptly if success is to be expected. A delay of three to five minutes will usually result in permanent central nervous system damage even if the heart beat is restored. Treatment of cardiac arrest consists of three phases: (1) the maintenance of respiration and the administration of oxygen; (2) the maintenance of circulation by manual compression of the heart; and (3) resuscitation of the heart. The first two must be carried out promptly and simultaneously, for the maintenance of adequate circulation by cardiac massage is of no value unless there is adequate oxygen in the pulmonary alveoli. When respiration and cardiac massage have been established, resuscitation of the heart can then be instituted.

Adequate respiration can best be established and maintained by use of an endotracheal tube. Pure oxygen should be administered. Manual compression of the chest or mouth-to-mouth insufflation may be used in the absence of better resuscitative equipment such as an endotracheal tube and anesthetic machine. The maintenance of respiration with endotracheal equipment not only aids in the oxygenation of blood, but also contributes to pulmonary circulation.

Cardiac massage is best carried out through the open thorax. Compression of the heart through the intact diaphragm or transdiaphragmatically through the open abdomen is unsatisfactory. Pounding on the precordium or the use of percutaneous intracardiac injections is not recommended. The chest is opened through the fourth intercostal space anteriorly with transection of anterior costal cartilages to obtain better exposure. Time is of the essence, so that aseptic technique may be impossible. If bleeding from the chest wall is a problem, the diagnosis is incorrect. A cardiac arrest tray should be available in all operating suites and recovery rooms; however, the only instrument required is a knife. Manual compression of the heart across both ventricles at a rate of sixty to eighty times a minute is instituted. Care should be taken to avoid displacement of the heart. Opening of the pericardium permits more efficient massage and enables one to determine the status of the myocardium. The effectiveness of massage can be determined by palpation of the carotid pulse by an assistant. The patient should be placed in the Trendelenburg position to improve circulation to the brain, and the blood volume should be maintained by use of whole blood or dextran. Compression of the aorta by an assistant produces better circulation to the coronary and cerebral circulations.

If the heart is in cardiac standstill or the pulsations are feeble, massage in itself may be sufficient to return the heart beat to its normal vigorous quality. However, the quality of beat may be increased by injecting epinephrine, 1:1,000, 0.5 cc. in ten per cent saline solution, or calcium chloride, 2 to 5 cc. of a 10 per cent solution.

When ventricular fibrillation is present, complete standstill must be produced by use of the electric defibrillator. While the defibrillator is being prepared for use, cardiac massage must be continued to maintain circulation. Electrical defibrillators by which a shock of approximately 110 to 220 volts at 1.5 amperes can be passed across both ventricles without danger to the operating personnel should be available in all operating suites. Electrodes approximately 2 inches in diameter, the surfaces of

which are covered with gauze which can first be moistened with saline solution, are placed on opposite surfaces of the ventricles. A shock of 110 to 220 volts at 1.5 amperes and of 0.1 second duration is first attempted. If this does not produce standstill or return to a normal rhythm, repeated shock should be attempted. Although defibrillation is not of the same urgency as is the early restoration of pulmonary ventilation and cardiac massage, the earlier electrical shock is applied, the better the prognosis. Procaine, 10 cc. of a 1 per cent solution, or procaine amide, 100 to 200 mg. may be used to lessen cardiac excitability if defibrillation proves difficult.

Cardiac massage and resuscitative measures should be continued and not abandoned until all signs of myocardial activity have ceased. Patients have been restored after having been maintained on cardiac massage for as long as two hours.

ASPIRATION OF PERICARDIUM (PERICARDIOCENTESIS)

General Considerations

Aspiration of the pericardium is indicated as a diagnostic or therapeutic measure in the treatment of serous or purulent pericardial effusions. Singleton recommended aspiration in cardiac compression (Herztamponade) following hemorrhage as a result of trauma. Aspiration may be sufficient to relieve tamponade, making operative intervention unnecessary, or may give temporary relief while preparations for operation are being completed.

Dangers and Safeguards

The dangers of pericardial aspiration are wounds of the heart muscle, injury of the coronary and internal mammary arteries, and injury of the peritoneum and pleura. Injury of the peritoneum and pleura when aspirating the pericardium may cause infection of these structures.

An aspirating needle should be inserted through the uncovered pericardial triangle (Voinitch-Sianojentsky "triangle of safety"). This irregularly triangular area is free from pleura. It is bounded above by a horizontal line crossing the lower margin of the fifth chondrosternal articulation and below by a horizontal line which crosses the seventh chondrosternal articulation and the base of the xiphoid cartilage. The long axis of the space lies 1.5 cm. to the left of the midline of the sternum parallel with a vertical line drawn through the seventh left chondrosternal joint. A needle introduced at the margin of the sternum in the left sixth interspace will enter the pericardium without wounding the internal mammary artery or pleura.

Technique of Pericardial Aspiration

The patient should be placed in a semirecumbent position. Local anesthesia is advised. The pericardium may be entered by introducing the needle through the fifth or sixth left interchondral space at the sternal margin or through the left costoxiphoid notch. If aspiration is done through the interchondral space, the needle should be introduced directly at a right angle to the sternum. If the needle is inserted in the left costoxiphoid notch, it should be directed upward, backward and slightly to the left. As the aspirating needle is slowly inserted, the plunger of the syringe should

be repeatedly withdrawn so that pus, fluid or blood will appear in the syringe as soon as the pericardium is entered. Pulsation of the heart transmitted to the syringe is an indication for immediate withdrawal of the needle. Pus is frequently not readily found by aspiration through *the costoxiphoid notch, since it tends to* accumulate in the posterior portion of the pericardial sac.

PERICARDIOSTOMY FOR SUPPURATIVE PERICARDITIS

General Considerations

Incision and drainage of the pericardium may be indicated in suppurative pericarditis. Aspiration of the pericardium combined with specific antimicrobial therapy both systemically and intrapericardially may control the infection. Many surgical approaches have been suggested for the drainage of purulent pericarditis, but it is now generally agreed that removal of one or more costal cartilages to the left of the sternum is the procedure of choice. A similar approach may be made to the right of the sternum in selected cases. Since pus tends to accumulate posterior to the heart, lateral and posterior approaches have been used by Loucks, Truesdale and others. Such incisions expose the pleura to the danger of infection and are not to be used routinely. Allingham suggested an extraperitoneal approach through the rectus muscle, *diaphragm and pericardium. This method may be applicable to some cases.* It has the advantage of avoiding the pleura and preserving the normal anatomy of the thoracic wall.

Dangers and Safeguards

The immediate and greatest danger of operation is shock. This should be anticipated and preparation made for its treatment before the operation is started. *Bleeding* from the internal mammary vessels may occur. Since the heart usually lies against the anterior pericardium, it may be wounded when the latter is incised. The pleura may be contaminated, with later development of *empyema*. The operative approach to *the pericardium should be made carefully to avoid damage to the* pleura. If the pleura is wounded, it should be closed immediately. If there is any doubt about secure closure of the pleura, it is advisable to pack the wound with gauze down to the pericardium and open the pericardium two to three days later.

As a rule, patients with pericarditis are quite ill as a result of a primary infection *in the lung, pleura, bone or elsewhere, plus the acute pericardial infection* Before the antimicrobial era the mortality rate was high, and the prognosis is still grave because of the frequency of associated sepsis in other areas.

Technique of Pericardiostomy (Fig. 301)

Local anesthesia may be used in some cases. Since many of the patients are small children, gas or light ether anesthesia may be the choice. The patient is placed on the table in the supine position. To improve the patient's comfort, the head and shoulders may be raised to a semirecumbent position.

Incision 1 (*Shipley*). A hockey-stick type of incision is made over the lower sternum and costal cartilages. It begins over the midline of the sternum at the level of

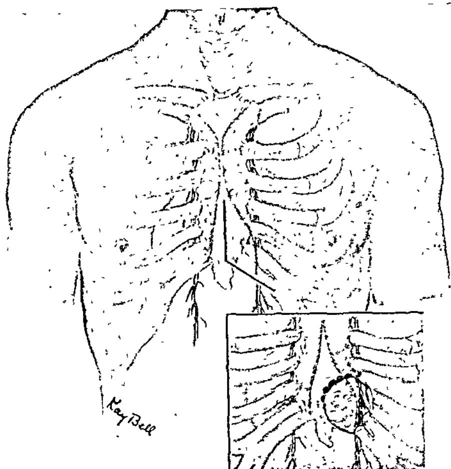


FIGURE 301. Technique of pericardiostomy Type of incision for exposure of pericardium Inset shows bone and costal cartilages removed with rongeur and knife. (Redrawn from Shipley· Surg., Gynec. & Obst.)

the fourth costal cartilage, extends directly downward to the ensiform articulation and turns outward along the left seventh costal cartilage to extend a distance of about 7 cm. All tissues are turned back as a flap from the sternum and lower costal cartilages. With a round burr which will not suddenly penetrate the sternum, an opening is made through the gladiolus just above its articulation with the ensiform. This opening is enlarged with the rongeurs until the left lateral segment of the sternum and the adjoining ends of the fifth and sixth costal cartilages are cut away. The enlarged opening uncovers the lower pericardium, left pleural flap, and internal mammary vessels in the "triangle of safety." The mammary vessels are doubly ligated or pushed to the left with the pleura. In children the opening need not be as large as in adults. In either children or adults the opening should be sufficiently large to permit the surgeon to pass the finger about the heart to locate pus pockets.

Incision 2. A hockey-stick incision is made beginning at the left margin of the sternum over the fourth costal cartilage and extending downward to the level of the sixth costal cartilage, where it curves outward along the cartilage for 4 to 6 cm. The fifth and sixth cartilages are excised and the fourth and seventh divided if necessary. The perichondrium and interchondral tissues are incised at the sternal margin, exposing the pericardium, left pleural margin, and the mammary vessels. The mammary vessels are doubly ligated and the pleura gently pushed and retracted to the left.

The uncovered pericardium should be incised with the greatest care, since the heart is usually in close proximity or actually adherent to the anterior pericardium.

If not too tense, the pericardium may be picked up between two forceps or hemostats and incised in much the same manner as the peritoneum is opened. When the pericardium is opened, there is usually a gush of pus due to increased intrapericardial pressure. The index finger is inserted and gently passed to each side of the heart and around the apex, freeing adhesions and opening accumulations of pus. All pus is removed by suction, and the pericardial cavity is carefully irrigated and cleansed with warm physiologic sodium chloride solution. Cleansing may be aided by passing a soft rubber catheter through which the solution may be injected beneath and to the sides of the heart. The heart must be handled with care, and any irregularity is a signal to discontinue manipulation until rhythm is restored. The margins of the pericardial wound are sutured to the fascia or skin, and the wound is left open.

Introduction of drainage material is rarely advisable, although some authors record the use of soft rubber tubes passed behind the heart and sutured to the skin. The pericardial sac may be irrigated by passing a soft rubber catheter about the heart each day until purulent drainage ceases.

REPAIR OF HEART WOUNDS

General Considerations

If evidence of intrapericardial pressure or heart tamponade ("Herzdruck, Herztamponade") exists following a penetrating wound in the cardiac region, immediate aspiration of the pericardium is indicated. Preparations are then made for operation and the patient observed carefully. A sudden increase in intrapericardial pressure causes a drop in arterial pressure and an increase in venous pressure. The heart sounds are diminished. If, after the first pericardial tap, signs of tamponade recur, the aspiration is repeated. If the pericardium continues to refill with blood after repeated aspiration, operation is indicated.

The surgical approach to the heart depends somewhat upon the location of the wound. It may be to the right of the sternum, through the sternum or to the left of the sternum. A majority of heart wounds may be exposed through an approach to the left of the sternum or by enlarging such an incision by clipping away a portion of the sternum.

Dangers and Safeguards

The immediate dangers are *hemorrhage* and *heart tamponade.* These may be rapid in onset, accompanied by the signs and symptoms of shock with cyanosis and marked respiratory distress. If pressure is not relieved at once, death may result within a short time, depending upon the size and location of the heart wound.

Although it is necessary to prepare the patient hurriedly, preparation should be done carefullv to avoid wound infection. Morphine should be given for restlessness. The patient should be kept warm. Since the pleura is frequently injured, a gas anesthetic with positive pressure equipment should be used. The operation may be started with local anesthesia, but after release of the tamponade, consciousness usually re-returns, and the patient will require inhalation anesthesia. The immediate dangers of the operation are hemorrhage from the heart wound when the pericardium is opened

and further injury to the heart muscle while attempting to place sutures. When placing the sutures, *the coronary vessels should be avoided.* Blood transfusion is indicated as soon as the heart wound is closed.

Technique of Heart Suture (Figs. *302, 303*)

The incision is usually made to the left side of the sternum unless the penetrating wound is far to the right. It may be made at any level which appears to be nearest the heart wound. If the wound is near the sternum and the pleura is not likely to be wounded, the incision should be made near the sternum, but if the pleura has been wounded, a transpleural intercostal approach may be most satisfactory.

A semicircular *incision is made with the curve overlapping the sternal margin.* This gives adequate exposure of the third, fourth and fifth costal cartilages and their adjoining rib ends. The incision is extended through all structures to the cartilages, and a flap of skin, muscle and fascia is dissected up to expose the underlying cartilages and the ends of the ribs beyond the costochondral junctions. The third, fourth and *fifth cartilages are divided and turned up as a flap.* The cartilages and, if necessary, portions of the ribs may be removed to obtain adequate exposure. A portion of the sternum may be cut away with rongeurs if additional exposure is needed. The mammary vessels are next dissected free and ligated at the upper and lower limits of the wound. The tissues near the sternum are divided and carefully dissected outward with

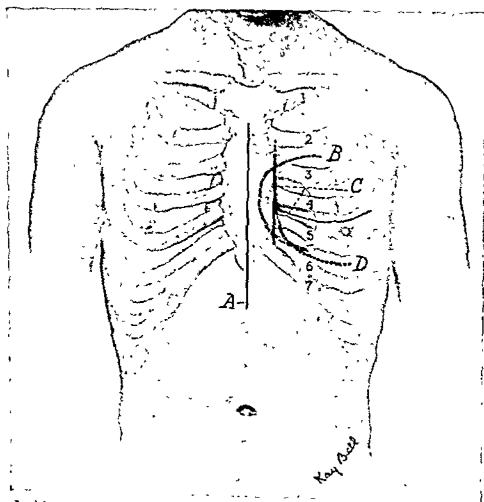


FIGURE 302 Incisions for exposure of the heart. *A*, Duval-Barasty midsternal incision. *B*, Semicircular incision. *C*, Sparango incision. *D*, Parasternal incision.

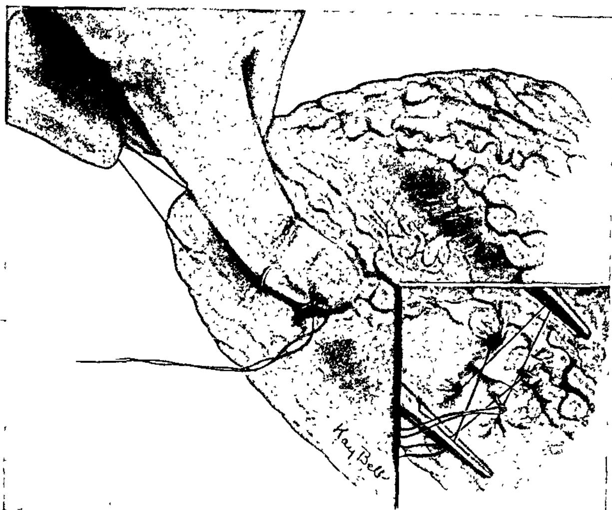


FIGURE 303. Suture of wound of ventricle. A traction suture is placed in the apex of the heart Control sutures are placed in the heart muscle on each side of the wound while bleeding is controlled with the index finger. Lateral traction on the control sutures prevents bleeding while the wound is being closed. (Redrawn from Beck: Med Ann Dist. of Columbia)

the pleura, exposing the pericardium. The pleura should not be cut or torn if it can be avoided. Wounds in the pleura may be guarded by moist packs during the operation and later sutured.

The pericardium is usually distended. The pericardial wound is located and enlarged to expose the heart wound. The pericardial blood is evacuated rapidly by suction and gauze sponging. As soon as the tamponade is relieved, the heart usually begins beating more vigorously, increasing the bleeding. The heart wound is located by the spurting blood. To control bleeding, digital pressure is made over the wound while the sutures are placed. The finger should not be inserted into the wound, since the heart muscle is friable, and the wound may be torn larger.

Elkin's method of suture is satisfactory. He passes a suture through the heart muscle beneath the finger compressing the wound and uses this suture to control bleeding while placing the approximating sutures to close the wound. The deep suture should be removed after wound repair, since it may have penetrated the endocardium. Beck first places a control suture in the heart apex, using this to steady the heart while wound control sutures are being placed on each side and parallel with the wound. The control sutures on each side of the wound are crossed, and bleeding is controlled by gentle traction. Care should be used not to tear the friable heart muscle. As soon as the wound sutures are placed and bleeding stopped, all control sutures are removed.

Interrupted sutures should be tied tightly enough to approximate the wound margins, but not tightly enough to cut the muscle. Fine arterial silk is the choice of suture material. Sutures should not penetrate the cardiac cavity. Coronary vessels should not be included in sutures when they can possibly be avoided.

Wounds passing through the heart making two openings into the cardiac cavity are more difficult to suture. Exposure is aided by twisting the heart with the Beck apex traction suture. This procedure may disturb the cardiac rhythm, and sometimes beats will cease altogether. Massage and injection of epinephrine into the right ventricle or atrium are used for resuscitation.

After the heart bleeding has been controlled the pericardium should be cleansed of all blood by irrigation with warm physiologic sodium chloride solution and closed with interrupted sutures, preferably of fine silk. If the pleura has been wounded, it is sutured after the lung has been inflated. The chest wound is closed airtight with fine plain catgut or silk in the muscle and subcutaneous tissues and silk in the skin. A soft rubber tissue drain may be placed beneath the skin flap to be removed in twenty-four to forty-eight hours if there is no evidence of infection.

Wounds in the *intrapericardial portions of the great vessels* at the base of the heart may be repaired by the same methods as described above for heart wounds.

REMOVAL OF FOREIGN BODIES FROM THE HEART AND PERICARDIUM

A great contribution was made to cardiac surgery during World War II by Dwight Harken, whose pioneering impetus led to the removal of a large number of foreign bodies of various types from the heart and great vessels. Knowledge gained during that time provided a stimulus and springboard for the development of intracardiac surgery.

When opening the pericardium for the removal of foreign bodies, the same methods of approach as used for heart wounds may be used. Since foreign bodies have been known to remain in the heart or pericardium for many years without serious results, cases for operation should be selected with great care. If a foreign body is to be removed from the heart wall or cardiac cavity, control sutures as noted above for the closure of heart wounds should always be used. If a sharp instrument, such as a knife blade, is found penetrating the heart muscle, it should not be withdrawn until the heart is exposed, so that the wound may be promptly closed to avoid excessive bleeding.

CHRONIC CONSTRICTIVE PERICARDITIS

General Considerations

As a result of chronic infection the heart may become encased in a thickened, rigid envelope of pericardium, frequently with calcification present, resulting in a slowly progressive compression of the cardiac musculature. The compression of the heart and great vessels may be due to actual contraction of the surrounding scar or to the pressure of fluid confined in the rigid-walled pericardium. In either event the results are the same, typically resulting in Beck's triad of the small quiet heart, ascites

and increased venous pressure. There may be present other evidences of circulatory failure such as pleural effusion, peripheral edema or enlargement of the liver, with an electrocardiogram exhibiting low voltage in the QRS complex and inversion of the T waves. This condition is seen most often in younger patients who, because of the similarity to cardiac failure from other causes, often go misdiagnosed or undiagnosed for long periods of time after the beginning of symptoms. Although this disease has been recognized since the time of Galen, its safe and effective management by operative removal of the constricting, scarred pericardium is of recent vintage. Holman and others have emphasized the necessity of wide excision of the pericardium, especially over the right heart and the two caval vessels where the degree of thickening is often greatest in order to assure success in the operation. In order to accomplish this, wide exposure of the heart is necessary.

Many of the early operative failures as well as fatalities resulted from inadequate surgical exposure. Holman showed that once the diagnosis of tuberculous pericarditis has been established and cardiac compression can be demonstrated, operation should not be delayed even though the tuberculous process may be active. The safety of this early operative approach has been increased markedly by the use of antituberculosis drugs.

In the preparation for operation the patients are given digitalis, and the accumulated ascitic and pleural fluid is removed by aspiration.

Technique of Operation for Constrictive Pericarditis (Holman) (Figs. 304 to 309)

Endotracheal anesthesia is necessary, since both pleural cavities may be entered. The patient is placed in the supine position, and the head of the operating table may be raised if indicated to increase the efficiency of pulmonary ventilation.

Adequate exposure is essential. This may be obtained with a transverse, transsternal incision opening both sides of the chest through the fourth intercostal space and transecting the sternum at that level, or by medium sternotomy as advocated by Holman.

An incision is made from the manubrium to below the xiphoid, curving to the left of the sternum. The skin and subcutaneous tissue are dissected back, exposing the

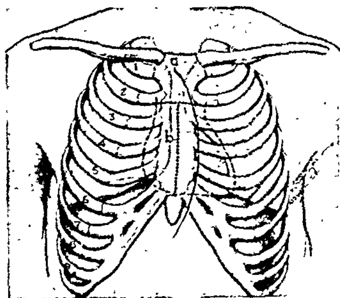


FIGURE 304 Pericardiectomy for constrictive pericarditis *a*, Vertical incision curved slightly to the left of the midline to avoid lying directly over the incision in the sternum *b*, The gladiolus is divided vertically, the xiphoid removed and the sternum divided horizontally at the level of the second intercostal space. (E Holman and F. Willett Surg, Gynec. & Obst, Vol 89)

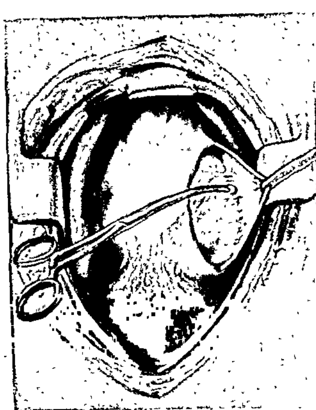


Fig. 305.

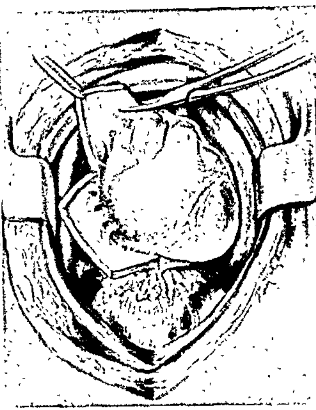


Fig. 306

FIGURE 305 Pericardiectomy for constrictive pericarditis (*continued*). The sternum has been separated and the mediastinal and areolar tissue and pleura separated over the pericardium. The thickened pericardium is incised over the left ventricle and a cautious dissection of the cleavage plane begun. The peel is removed laterally as far as the left phrenic nerve and superiorly from the region of the aorta and pulmonary artery. As dissection proceeds the peel is not removed. In the event of injury to the heart muscle the peel may be used as a patch to close the wound. (E. Holman and F. Willett: Surg., Gynec & Obst., Vol. 89)

FIGURE 306 Pericardiectomy for constrictive pericarditis (*continued*). When the peel has been removed from the left side of the heart, the dissection proceeds to the anterior wall of the right ventricle and right atrium. Extreme care must be used in the region of the right atrium since the peel may be much thicker than the myocardial wall (E Holman and F. Willett: Surg., Gynec. & Obst , Vol. 89.)

sternum. The xiphoid is removed and the sternum divided vertically to a level of the second intercostal space, taking care not to injure the underlying structures. The sternum is then divided horizontally at the level of the second interspace and the two halves separated with a rib spreader. The mediastinal areolar tissue and pleura on both sides are separated as far laterally as possible. The pericardium is then incised carefully over the area of the left ventricle and a cleavage plane found. The peel may be laminated, and the innermost layer must be removed. When the cleavage plane has been identified, the rind is mobilized cautiously to the left as far laterally as the left phrenic nerve if this can be identified. The pericardium should not be cut away immediately, but should be used for traction, since it may be of great value in controlling hemorrhage in case an accidental wound is made through the heart muscle. Closure of such a wound is made much easier if the pericardium is available to suture over the opening in the torn muscle. Wounds in the right ventricle or atrium, where they are most likely to occur, are difficult to control because of the great friability of the muscle.

Sharp dissection may be necessary in some places, although careful, blunt or finger dissection is preferable when possible. The use of "peanut" dissectors is often

helpful. As the constricting peel is removed, the heart muscle will be seen to protrude through the removed area, often beating with a visibly improved quality. An improvement in the patient's ventilatory capacity, blood pressure and pulse is often discernible to the anesthesiologist as the dissection continues. The left ventricle is freed first in order to increase delivery of blood to the systemic circulation and avoid increased strain on the weaker and thinner-walled right side of the heart. Special care must be exercised in separating the scar from the region of the coronary vessels where it is apt to be densely adherent, and small patches of peel may be left in place if its removal seems unduly hazardous. The dissection is next carried over the anterior wall of the right ventricle.

Difficult dissection may be encountered at the interventricular and atrioventricular grooves. The atrioventricular groove should be freed if possible. The peel is next freed upward off the pulmonary artery and aorta. Extreme care must be used in freeing the right atrium where the myocardium may be thin and friable, indeed much thinner than the overlying scar. If its removal seems unduly hazardous, the scarred pericardium may be incised along the atrioventricular groove and the base of the heart, leaving the intervening pericardium attached to the right atrium. This does not seriously hamper the beneficial effects of the operation.

The right border of the heart is further liberated by dissecting the peel away from the inferior and superior venae cavae, carrying the dissection as far laterally as the right phrenic nerve, which should not be injured. Removal of the constricting scarred pericardium from the inferior vena cava where it pierces the diaphragm is extremely important to the success of the operation. The scar between the anterior inferior border of the heart and the diaphragm is often extremely thickened and difficult to remove. Occasionally calcification of the pericardium has occurred to such a degree that rongeurs are required for its removal. When the heart and great vessels have been completely freed of the constricting scar, the operative field is flushed with warm saline solution.

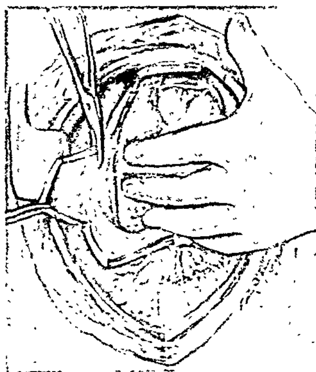


FIGURE 307. Pericardiectomy for constrictive pericarditis (*continued*). The dissection is carried to the right as far as the right phrenic nerve. The peel must be removed from the superior and inferior venae cavae to avoid obstruction of venous return from the heart. (E. Holman and F. Willett. Surg., Gynec. & Obst., Vol. 89.)



FIGURE 308 Pericardiectomy for constrictive pericarditis (*continued*). The peel is next removed from the diaphragmatic surface of the heart and the inferior vena cava. This usually represents the thickest portion of the peel, and definite calcification may be present. (E Holman and F. Willett· Surg., Gynec & Obst., Vol 89.)

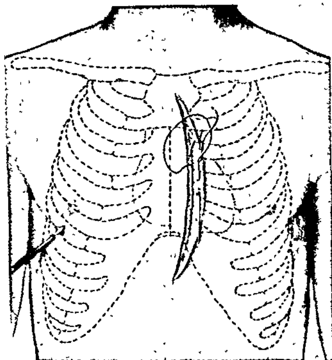


FIGURE 309. Pericardiectomy for constrictive pericarditis (*concluded*). When decortication of the heart is completed, the sternum is reapproximated with 2 heavy steel wires. If the pleural cavity has not been entered during the dissection, this is opened deliberately and intercostal waterseal drainage established If both pleural spaces have been entered, bilateral intercostal waterseal drains are used The wound is then closed in layers (E Holman and F Willett: Surg , Gynec. & Obst , Vol. 89)

If both pleural cavities have been opened, intercostal waterseal drainage tubes are placed in both pleural cavities before closure. If neither pleural space has been opened, the right pleura is deliberately opened and a drain placed through an intercostal stab wound. There is often a large quantity of serosanguineous drainage due to the large denuded area. This is especially true if active disease is present. The sternum is then reapproximated with two heavy steel wires placed in the bony portion of the sternum and the fascia and the subcutaneous tissue approximated with interrupted silk.

Postoperatively, there will be a prompt return of the venous pressure to normal

helpful. As the constricting peel is removed, the heart muscle will be seen to protrude through the removed area, often beating with a visibly improved quality. An improvement in the patient's ventilatory capacity, blood pressure and pulse is often discernible to the anesthesiologist as the dissection continues. The left ventricle is freed first in order to increase delivery of blood to the systemic circulation and avoid increased strain on the weaker and thinner-walled right side of the heart. Special care must be exercised in separating the scar from the region of the coronary vessels where it is apt to be densely adherent, and small patches of peel may be left in place if its removal seems unduly hazardous. The dissection is next carried over the anterior wall of the right ventricle.

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The right border of the heart is further liberated by dissecting the peel away from the inferior and superior venae cavae, carrying the dissection as far laterally as the right phrenic nerve, which should not be injured. Removal of the constricting *scarred pericardium from the inferior vena cava where it pierces the diaphragm* is extremely important to the success of the operation. The scar between the anterior inferior border of the heart and the diaphragm is often extremely thickened and difficult to remove. Occasionally calcification of the pericardium has occurred to such a degree that rongeurs are required for its removal. When the heart and great vessels have been completely freed of the constricting scar, the operative field is flushed with warm saline solution.



FIGURE 307 Pericardiectomy for constrictive pericarditis (*continued*). The dissection is carried to the right as far as the right phrenic nerve The peel must be removed from the superior and inferior venae cavae to avoid obstruction of venous return from the heart (E. Holman and F Willett Surg, Gynec & Obst., Vol. 89)



FIGURE 308. Pericardiectomy for constrictive pericarditis (*continued*). The peel is next removed from the diaphragmatic surface of the heart and the inferior vena cava. This usually represents the thickest portion of the peel, and definite calcification may be present. (E Holman and F. Willett: Surg., Gynec & Obst, Vol 89)

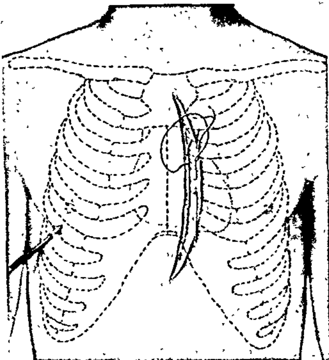


FIGURE 309. Pericardiectomy for constrictive pericarditis (*concluded*) When decortication of the heart is completed, the sternum is reapproximated with 2 heavy steel wires If the pleural cavity has not been entered during the dissection, this is opened deliberately and intercostal waterseal drainage established. If both pleural spaces have been entered, bilateral intercostal waterseal drains are used. The wound is then closed in layers (E Holman and F Willett Surg, Gynec. & Obst, Vol. 89.)

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Postoperatively, there will be a prompt return of the venous pressure to normal

helpful. As the constricting peel is removed, the heart muscle will be seen to protrude through the removed area, often beating with a visibly improved quality. An improvement in the patient's ventilatory capacity, blood pressure and pulse is often discernible to the anesthesiologist as the dissection continues. The left ventricle is freed first in order to increase delivery of blood to the systemic circulation and avoid increased strain on the weaker and thinner-walled right side of the heart. Special care must be exercised in separating the scar from the region of the coronary vessels where it is apt to be densely adherent, and small patches of peel may be left in place if its removal seems unduly hazardous. The dissection is next carried over the anterior wall of the right ventricle.

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FIGURE 307. Pericardiectomy for constrictive pericarditis (*continued*). The dissection is carried to the right as far as the right phrenic nerve. The peel must be removed from the superior and inferior venae cavae to avoid obstruction of venous return from the heart. (E. Holman and F. Willett: Surg., Gynec. & Obst., Vol. 89.)



FIGURE 308 Pericardiectomy for constrictive pericarditis (*continued*) The peel is next removed from the diaphragmatic surface of the heart and the inferior vena cava This usually represents the thickest portion of the peel, and definite calcification may be present. (E Holman and F. Willett: Surg., Gynec. & Obst, Vol 89.)

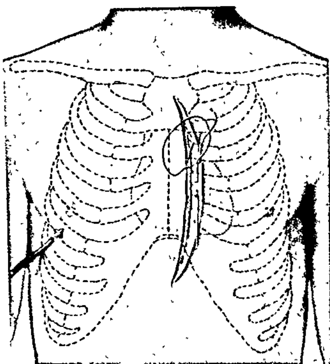


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Postoperatively, there will be a prompt return of the venous pressure to normal

if decortication has been complete. Since myocardial activity has been impaired markedly during the preoperative period in much the same manner that the muscles of an extremity are mobilized in a cast after fracture, a return to normal physical activity after operation should be on a gradual basis. If the excised specimen shows any evidence of active tuberculosis, prolonged postoperative use of antituberculosis drugs should be made. Evidence of improved myocardial function can be observed by the electrocardiogram with improvement of the QRS voltage and a return to an upright T wave.

CLOSURE OF PATENT DUCTUS ARTERIOSUS

General Considerations

The successful ligation of a patent ductus arteriosus by Gross in 1938 marked the beginning of a new era in cardiac surgery. Since that time thousands of patients having this type of congenital anomaly have been treated surgically with a high degree of success. In the beginning it was the practice to close a patent ductus arteriosus with multiple ligatures of various types, and indeed the ligation technique is still recommended by some authors. However, because of the occasional failure to obtain obliteration as well as a certain percentage of recanalization using this technique, complete severance of the ductus with separate closures of the pulmonic and aortic ends is the procedure most generally recommended. Since the operation has been standardized and can be carried out with negligible operative mortality, the establishment of a diagnosis of patent ductus is generally considered adequate indication for operation. Even though many patients having a patent ductus arteriosus are asymptomatic, and a few may live a full life span, study of a large series of untreated cases has shown a high percentage of late incapacitation and shortening of life due to cardiac failure or superimposed bacterial infection. In patients having a superimposed bacterial infection of the ductus, intensive treatment with antibiotics in an effort to sterilize the blood stream should be carried out before operation.

The optimal age for operation is considered to be between the ages of six and twelve years. In the face of retarded development or evidence of cardiac failure, operation should be carried out regardless of age of the patient. In the adult, operation may be somewhat more difficult, owing to inelasticity of the vessel walls.

Gross recommends ether-oxygen anesthesia and uses an anterolateral approach Others prefer the posterolateral approach, using an intercostal incision in children and removing the fourth or fifth rib in adults.

Technique of Complete Surgical Division of Patent Ductus Arteriosus (Gross) (Figs. 310, 311)

The patient is placed on his back with the left arm extended upward and the left side of the chest and shoulder slightly elevated. The incision is made below the breast from the lateral margin of the sternum and carried around laterally high in the axilla to the posterior axillary level. The chest is then entered through the third intercostal space by dividing the intercostal muscles. The internal mammary vessels may be ligated if necessary. The second and third costal cartilages are divided near the

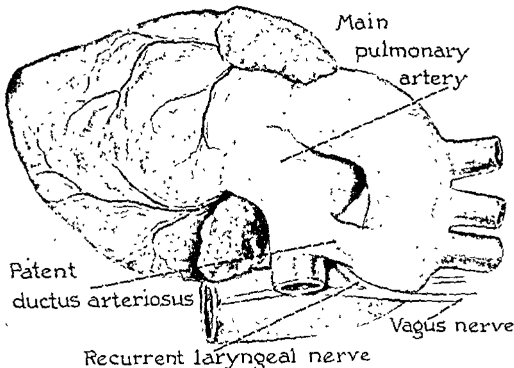


FIGURE 310. Drawing of heart and great arteries, illustrating relationship of these structures and the presence of a patent ductus arteriosus between the aorta and pulmonary artery. (Gross: The Surgery of Infancy and Childhood)

sternum and the wound held open with a rib spreader. The lung is collapsed and retracted downward and forward to expose the base of the heart. The phrenic nerve is identified as it passes over the arch of the aorta, and an incision is made through the mediastinal pleura posterior to the phrenic nerve 7 to 8 cm. in length. Ligation of the highest intercostal vein may be necessary to obtain better exposure. Beneath the pleura a fine network of fat and arealor tissue is found filling the sulcus between the aortic arch and pulmonary artery. Time and patience may be required to locate the ductus. It may at first appear that there is only a direct opening between the vessels.

Gross uses three methods of locating the vessel: (1) the ductus lies just opposite or slightly distal to the origin of the left subclavian artery; (2) the ductus may be compressed with temporary disappearance of the thrill over the heart and pulmonary artery; (3) the recurrent laryngeal nerve is located where it curves around the aortic arch a few millimeters posterior to the ductus. Following this nerve will lead directly to the ductus. The recurrent nerve must be identified and avoided during the subsequent dissection. The ductus is then isolated by careful blunt and sharp dissection. The extension of the pericardium is dissected upward and off the front of the ductus and pulmonary artery, keeping the pericardial sac intact if possible. A right-angled clamp is passed behind the ductus and a heavy braided silk thread passed around the ductus for traction purposes. By exerting gentle traction on the braided silk, dissection behind and medial to the ductus can now be carried out with safety. When sufficient length has been obtained, a right-angled clamp is spread behind the ductus and two ductus clamps placed on the ductus. Additional clamps are then placed so that four have been squeezed onto the ductus. The vessel is then divided with a knife between the two middle instruments, leaving two clamps on either end.

if decortication has been complete. Since myocardial activity has been impaired markedly during the preoperative period in much the same manner that the muscles of an extremity are mobilized in a cast after fracture, a return to normal physical activity after operation should be on a gradual basis. If the excised specimen shows any evidence of active tuberculosis, prolonged postoperative use of antituberculosis drugs should be made. Evidence of improved myocardial function can be observed by the electrocardiogram with improvement of the QRS voltage and a return to an upright T wave.

CLOSURE OF PATENT DUCTUS ARTERIOSUS

General Considerations

The successful ligation of a patent ductus arteriosus by Gross in 1938 marked the beginning of a new era in cardiac surgery. Since that time thousands of patients having this type of congenital anomaly have been treated surgically with a high degree of success. In the beginning it was the practice to close a patent ductus arteriosus with multiple ligatures of various types, and indeed the ligation technique is still recommended by some authors. However, because of the occasional failure to obtain obliteration as well as a certain percentage of recanalization using this technique, complete severance of the ductus with separate closures of the pulmonic and aortic ends is the procedure most generally recommended. Since the operation has been standardized and can be carried out with negligible operative mortality, the establishment of a diagnosis of patent ductus is generally considered adequate indication for operation. Even though many patients having a patent ductus arteriosus are asymptomatic, and a few may live a full life span, study of a large series of untreated cases has shown a high percentage of late incapacitation and shortening of life due to cardiac failure or superimposed bacterial infection. In patients having a superimposed bacterial infection of the ductus, intensive treatment with antibiotics in an effort to sterilize the blood stream should be carried out before operation.

The optimal age for operation is considered to be between the ages of six and twelve years. In the face of retarded development or evidence of cardiac failure, operation should be carried out regardless of age of the patient. In the adult, operation may be somewhat more difficult, owing to inelasticity of the vessel walls.

Gross recommends ether-oxygen anesthesia and uses an anterolateral approach. Others prefer the posterolateral approach, using an intercostal incision in children and removing the fourth or fifth rib in adults.

Technique of Complete Surgical Division of Patent Ductus Arteriosus (Gross) (Figs. 310, 311)

The patient is placed on his back with the left arm extended upward and the left side of the chest and shoulder slightly elevated. The incision is made below the breast from the lateral margin of the sternum and carried around laterally high in the axilla to the posterior axillary level. The chest is then entered through the third intercostal space by dividing the intercostal muscles. The internal mammary vessels may be ligated if necessary The second and third costal cartilages are divided near the

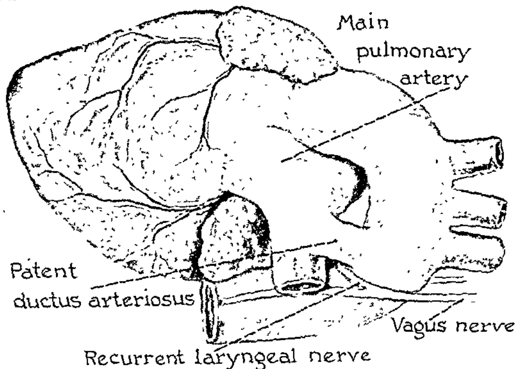
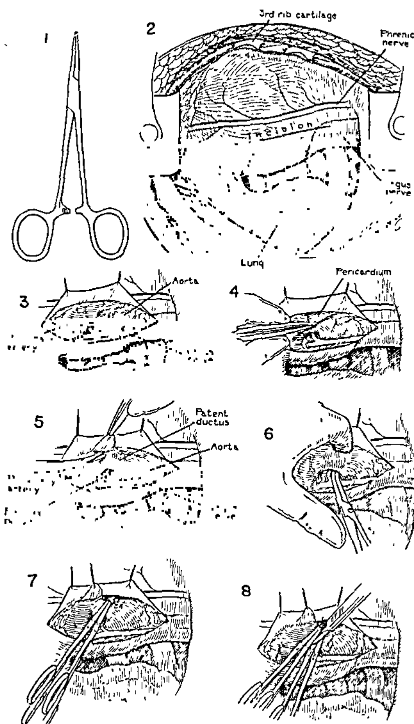


FIGURE 310. Drawing of heart and great arteries, illustrating relationship of these structures and the presence of a patent ductus arteriosus between the aorta and pulmonary artery. (Gross: The Surgery of Infancy and Childhood.)

sternum and the wound held open with a rib spreader. The lung is collapsed and retracted downward and forward to expose the base of the heart. The phrenic nerve is identified as it passes over the arch of the aorta, and an incision is made through the mediastinal pleura posterior to the phrenic nerve 7 to 8 cm. in length. Ligation of the highest intercostal vein may be necessary to obtain better exposure. Beneath the pleura a fine network of fat and arealor tissue is found filling the sulcus between the aortic arch and pulmonary artery. Time and patience may be required to locate the ductus. It may at first appear that there is only a direct opening between the vessels.

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A

The distal clamp on the pulmonary side is then removed, and the cuff is sewed over and over with 5-0 silk suture. This suture may be run back over the cuff to make an interlacing closure. The distal clamp on the aortic side is then removed and the cuff closed in a similar fashion, using a running continuous suture. After the closures have been completed a pack is placed between the vessels and the back clamps removed This permits clotting in the suture holes Occasionally a few secondary stitches may be placed for reinforcement. The chest wall is then closed in layers after re-expansion of the lung.

The patients are usually allowed out of bed on the fourth or fifth postoperative day and can be ambulatory shortly after that. They are allowed increasing physical

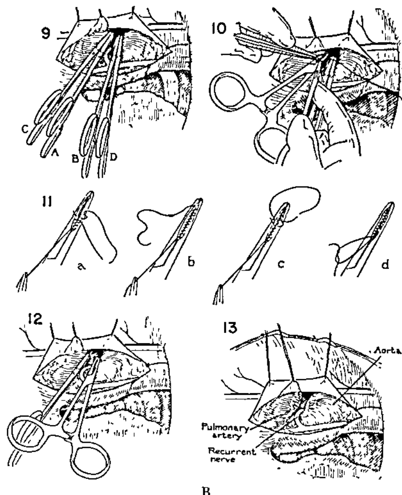


FIGURE 311. Complete division of patent ductus arteriosus. *1,* Special clamp used for application to the ductus *2,* The chest has been opened through the third intercostal space anteriorly, and the second and third costal cartilages have been divided near the sternum The lung is retracted posteriorly, and the mediastinum is opened posterior to the phrenic nerve. *3–6,* The ductus is isolated from surrounding *structures The pericardium is dissected off the ductus and pulmonary artery,* keeping the pericardial sac intact if possible. Passage of a heavy braided silk suture around the ductus for traction purposes simplifies dissection behind and medial to the ductus. *7–9,* Four clamps are placed on the ductus, which is divided between the 2 middle instruments *10,* The presenting clamp on the pulmonary artery side is removed and the cuff sewed over and over with 5-0 silk suture *11,* Details of the back-and-forth over-and-over interlocking suture. *12,* The pulmonary end of the ductus has been closed, and the presenting clamp on the aortic end has been removed preparatory to closure of the aortic cuff in the same fashion as used for the pulmonary cuff *13,* The clamps have been removed, and the closed ends of the ductus are shown. (R. Gross· Surgical Treatment for Abnormalities of the Heart and Great Vessels. Charles C Thomas, 1947)

activity and are ordinarily back to complete and unrestricted activity one month after operation.

COARCTATION OF THE AORTA

General Considerations

Developmental constrictions may occur in the aorta anywhere from the midpart of the arch to the bifurcation; however, 98 per cent of such constrictions occur in the first portion of the descending aorta just beyond the arch. Most patients with coarctation do not have symptoms, since sufficient collateral circulation develops to provide

sufficient blood flow below the area of constriction; and in fact a certain percentage of patients will live into adult life, some to old age with little incapacitation. However, the life expectancy of patients having coarctation is considerably less than the normal expectancy, and many suffer complications such as bacterial endocarditis, aortitis, rupture of the aorta, cardiac failure or cerebral hemorrhage secondary to the hypertension which inevitably develops in the upper portion of the body.

Operative correction of this defect by resection of the stenosed area and re-anastomosis of the aorta was developed in 1949 by Crafoord and Gross independently. Since that time numerous patients have been operated on successfully for coarctation.

In general, all patients having coarctation should be operated upon at an appropriate time, provided there are no serious contraindications. Such coexisting conditions as serious rheumatic mitral disease, aortic valve regurgitation, serious conduction bundle defects or advanced myocardial damage have been found to increase the operative risk enormously and usually contraindicate operation.

The optimal age for operation is between ten and eighteen years. By the age of ten the aorta is usually of sufficient size to permit easier manipulation and to provide a sizable lumen, while beyond this age operation is often complicated by difficulties in exposure, loss of aortic elasticity, and an increase in collateral vessels and aneurysms in the distal segment. In general, operation in infancy should not be done, although, if cardiac failure cannot be controlled, operation can be undertaken. In patients beyond the age of thirty-five years myocardial damage may increase the operative risk considerably.

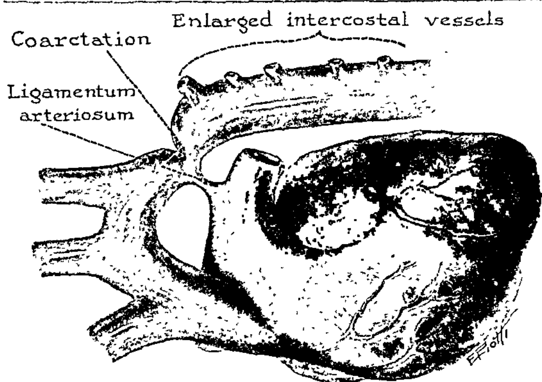


FIGURE 312. Drawing of the heart and great vessels to show the usual position of coarctation of the aorta. Although coarctation may occur throughout the aorta, 98 per cent are located in the first part of the descending aorta, usually near the ligamentum arteriosum. (Gross The Surgery of Infancy and Childhood.)

The operative procedure of choice is excision of the stenosed area and the re-establishment of arterial continuity by end-to-end anastomosis or by graft when the stenosed area is too long to permit reanastomosis of the aorta directly. The procedure of utilizing the dilated left subclavian artery for anastomosis to the distal end of the segment of aorta beyond the obstruction was formerly used when direct reanastomosis could not be carried out. This type of operation has been abandoned, however, in favor of grafting procedures.

Since blood loss frequently is considerable, provision should be made for the administration of large quantities of blood during operation.

Technique of Operation (Gross) (Figs. 313, 314)

Because of the tremendous increase in vascularity due to the increased collateral circulation, wide exposure of the operative field is necessary. The patient is placed on the right side and rotated forward to a semiprone position. A curved incision is made medial to the scapula, beginning near the spine over the second rib and extended downward and outward to the nipple line anteriorly. The muscle layers are divided and all bleeding points carefully ligated. The pleural cavity is then entered by dividing the fourth intercostal space widely. Additional exposure is then obtained by dividing the two ribs above and two ribs below posteriorly near the angle. In large subjects three ribs may be divided below. One intercostal bundle above and two below the fourth interspace are then clamped, divided and ligated. This permits wide exposure of the operative area. The lung is retracted medially, and the parietal pleura over the aorta is incised and mobilized. Dissection of the vessels is begun by first raising the left subclavian artery from its bed and placing a tape around it. Next the aorta well below the area of coarctation is mobilized and a tape passed around it for traction purposes.

By exerting gentle traction on this tape it is possible to develop the aorta upward and have adequate exposure of the delicate intercostal arteries at their origin from the aorta. An effort is made to preserve as many of these as possible, although one or two sets of intercostals may have to be divided and ligated in the area of the coarctation to permit sufficient tissue for ligation. These vessels can usually be occluded temporarily by small serrefine clamps, thus retaining as much collateral as possible. As the dissection is carried upward, the bronchial arteries as they emerge from the aorta are clamped, divided and ligated. When the aorta has been mobilized sufficiently, non-crushing clamps are applied above and below the constriction and the coarcted portion of the aorta excised. Any suitable artery clamp may be used; however, when the constriction is near the margin of the subclavian, a curved Satinsky type of clamp should be placed in such a manner to occlude the aorta above the origin of the subclavian. When the area of coarctation has been excised, continuity is re-established by anastomosing the two ends of aorta. Interrupted mattress sutures of 5-0 arterial silk are used to effect the anastomosis.

When the anastomosis has been completed, the lower clamp is removed so that blood can come back into the anastomosis under low pressure. Any leaks present are closed with additional sutures. The upper clamp is then slowly removed over a period of two or three minutes and the suture line observed for possible leaks. The pleural flaps can now be united over the aorta and the chest wall closed. An intercostal water-

seal drainage tube is inserted and left in place for three to four days after operation. Patients are usually allowed out of bed in four or five days and gradual activity resumed with return to full physical activity in five to six weeks after operation.

When the area of constriction is too long to permit excision and end-to-end anastomosis of the aorta, the gap can be bridged by use of an aortic homograft or plastic prosthesis.

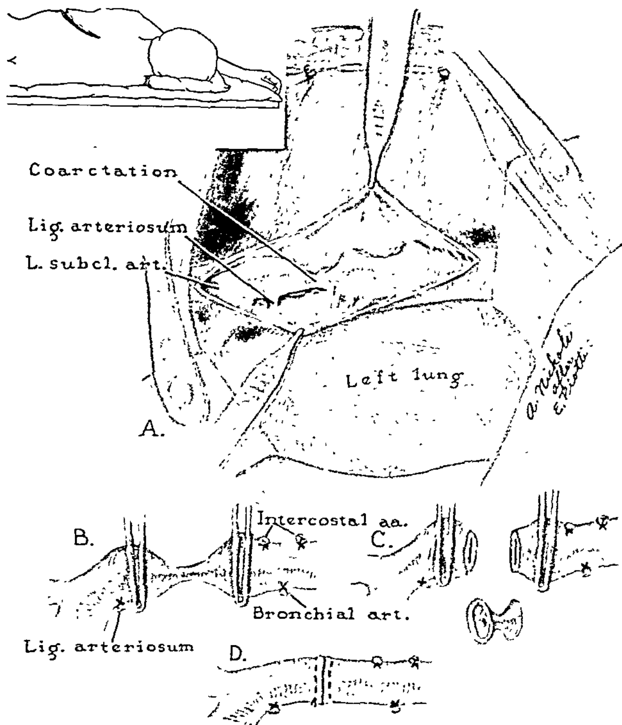


FIGURE 313. Technique of surgical treatment of coarcation of aorta Inset shows position of patient on the operating table, and line of incision. *A*, General view of operative field after exposure of coarctation. *B*, Intercostal arteries, bronchial artery and ligamentum arteriosum divided and ligated Clamps applied to aorta. *C*, Segment of aorta has been excised *D*, End-to-end anastomosis of aorta with continuous, everting mattress type of silk suture. (Redrawn from Gross: Surgery, Vol 18)

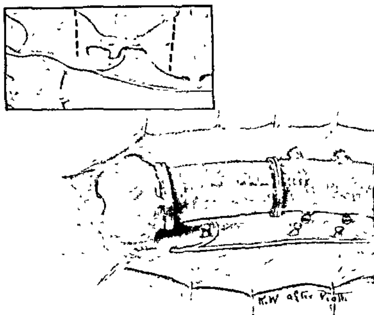


FIGURE 314. Technique of surgical treatment of coarctation of the aorta. Use of arterial homograft to bridge the defect when an end-to-end anastomosis cannot be made.

ANOMALIES OF THE AORTIC ARCH AND ITS BRANCHES

General Considerations

Many anomalies of the aortic arch and its branches have been described. The aortic arch may be on the right, the arch passing anterior to the trachea or behind the esophagus. The aortic arch may be double with the trachea between. The subclavian and carotid arteries may be anomalous on either side and compress the esophagus or trachea. Compression of the esophagus or trachea may be sufficient to produce symptoms requiring relief by operation.

Technique of Operation for a Double Aortic Arch (Gross and Ware) (Fig. 315)

An anterior incision is made through the left chest wall. Adequate exposure of the superior mediastinum is necessary to identify the aortic arch and all its branches.

The anterior arch is divided between the origins of the left subclavian and left common carotid arteries. The left common carotid artery is lifted off the trachea and held forward by suturing its adventitia to the periosteum behind the sternum with silk stitches.

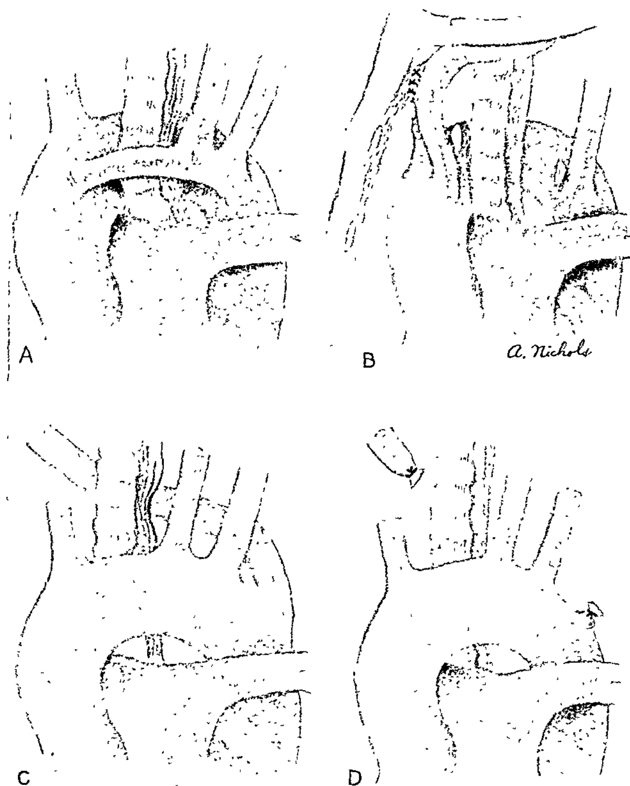
The left lung is expanded, and the chest wound is closed without drainage.

Technique of Operation for an Anomalous Right Subclavian Artery (Gross and Ware) (Fig. 315)

The superior mediastinum is explored through an anterior left transpleural incision.

The right subclavian artery is freed from its position behind the esophagus, doubly ligated and divided. The thoracic duct must not be injured by the dissection. The distal end of the vessel retracts to the right behind the esophagus.

After expanding the lung, the chest wound is closed without drainage.



[illegible] 315 Technique of surgical treatment of aortic arch anomalies. *A*, Double aortic arch [illegible] pulmo- [illegible] *common carotid artery and left* subclavian artery. The left carotid artery is sutured [illegible] the sternum to relieve the pressure on the trachea *C*, Anomalous right subclavian artery arising from the left side of the aortic arch and compressing the posterior wall of the esophagus *D*, The subclavian artery *has been divided to relieve the pressure on the esophagus* (Redrawn *from Gross* and Ware: Surg, Gynec & Obst, Vol 83)

PULMONIC STENOSIS

General Considerations

Congenital diminution of the pulmonary artery outflow tract, either of the valve itself or of the infundibular area below the pulmonic valve, may be of the "pure" type or may be combined with other cardiac anomalies. When combined with an interventricular septal defect, dextroposition of the aorta and hypertrophy of the right ventricle, this is known as the tetralogy of Fallot. This group of changes constitutes the most frequent cause of cyanotic heart disease in infancy and childhood. The most important physiologic defect in the tetralogy of Fallot is the inadequacy of blood flow to the lungs. To correct this abnormality, Blalock devised an operation to divert systemic blood into the pulmonary arterial system by anastomosing the right subclavian artery to the right pulmonary artery in an end-to-side fashion. Potts modified this procedure by making a side-to-side anastomosis between the aorta and pulmonary artery. These operations in effect produce a patent ductus arteriosus, permitting aortic blood flow into the pulmonary system, and are of course noncurative. However, such operations are associated with a fairly low operative mortality rate, and many patients have been markedly benefited for a long period of time after a shunting type of operation. The shunting type of procedures are contraindicated in patients having "pure" pulmonic stenosis.

Such patients are best handled by a direct attack on the obstruction in the right ventricular outflow. This can be done blindly by introducing instruments directly into the right ventricle and into the stenosed area for dilatation, or by introducing instruments into the pulmonary artery and dilating the stenosed area from above. With the use of hypothermia and with the advent of safe methods of producing extracorporeal circulation, these defects can be attacked directly. By using a pump oxygenator, the entire blood supply can be diverted from the heart and the heart and great vessels opened and the defects repaired under direct vision. As these methods are perfected so that they are attended with a low operative risk, there will be little place for the shunting type of procedures.

Technique of Operation (Blalock) (Figs. 316, 317)

The operative approach should be made on the side on which the innominate artery is located. If the aorta is on the right, the innominate is on the left. When the innominate artery is exposed, one may choose the innominate artery, the subclavian artery or the carotid artery for anastomosis, depending upon the inadequacy of the flow of blood to the lungs and the sizes of the vessels.

Ether or cyclopropane is used as an anesthetic. With the patient lying on his back, an incision is made in the third interspace extending from the lateral border of the sternum to the midaxillary line. After entering the pleural cavity, *the third and* fourth costal cartilages are severed. Good exposure is obtained by retracting the ribs with a rib spreader.

The innominate artery, or another artery selected for anastomosis, is carefully dissected free and occluded temporarily near the *aorta with a* bulldog clamp. Any branches which interfere with mobilization of the artery are divided and ligated. The pulmonary artery is freed of its adventitia and made ready for anastomosis. The artery

AZYGUS V. (CUT)
R COMMON CAROTID
R SUBCLAVIAN A.
PULMONARY A.
INNOMINATE A

FIGURE 316. Technique of anastomosis between the right subclavian and right pulmonary arteries The right common carotid, subclavian, innominate and pulmonary arteries have been dissected free ready for anastomosis. (Blalock: Ann. Surg., Vol. 124)

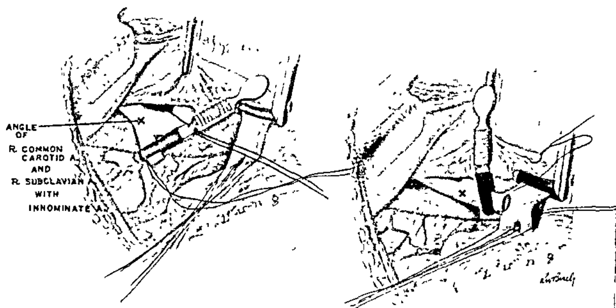


FIGURE 317 Technique of anastomosis between the right subclavian and right pulmonary arteries *(concluded)* *The proximal end of the subclavian artery is shown freed, divided and transposed.* The transposed artery makes an angle of approximately 90 degrees with its parent vessel. (Blalock: Ann Surg., Vol. 124.)

selected for anastomosis is divided far enough from its origin to unite with the pulmonary artery without tension and too much angulation. The distal end of the artery is ligated. Bulldog clamps are placed on the pulmonary artery proximal and distal to the site of anastomosis.

A transverse opening is made in the pulmonary artery the same length as the diameter of the severed systemic vessel. The anastomosis is made with fine silk placed so that the margins of the openings are everted to approximate intima to intima.

The chest wound is closed with silk. Braided silk is used to encircle and approximate the ribs. The muscles and skin are closed in layers.

ATRIAL SEPTAL DEFECTS

An opening in the wall between the two atria is one of the most common congenital cardiac anomalies. These intra-atrial septal defects vary greatly in size and position and may even be multiple. The presence of such a defect allows shunting of blood from the left to the right atrium, thereby increasing the flow through the right side of the heart and through the pulmonary circulation. When such a defect is small, it may be well tolerated and permit a long and active existence. However, when the quantity of blood shunted from left to right is large, right-sided heart failure results. During recent years several different methods have been devised to permit closure of these defects. And only time can determine which method is the safest and most effective. The methods of closure have been both indirect and direct.

"*Indirect Methods.*" ATRIAL TRANSFIXION. Septal defects can be closed or at least the size diminished by passing large mattress sutures of silk through the heart approximately in the plane of the atrial septum. When such sutures are tied, the heart is compressed in an anteroposterior plane, resulting in a diminution in size of the septal defect.

INVAGINATION OF ATRIAL APPENDAGES. Attempts have been made to close the defect by invaginating the atrial appendages, or the lateral wall of the atrium into the defect to act as a plug. The inverted appendage is held in position by sutures.

"*Direct Approach.*" VENA CAVAL OCCLUSION. By using hypothermia it is possible to occlude the caval inflow to the heart temporarily and to open the heart and close the atrial septal defect directly. Even with refrigeration, the time available for closure of the defect is only a few minutes, and there also is a danger of producing air embolization.

ATRIAL WELL TECHNIQUE. Gross and others have used a rubber bag, or "well," which can be sewed to the enlarged right atrium and the atrium opened inside the area to which the lower portion of the "well" has been sewed. When an opening is made in the atrium, blood rises in the "well" to a distance equal to the intra-atrial pressure. Instruments and the finger can then be passed through the pool of blood and opening into the area of the atrial septum and the defect closed by direct suture. This method necessitates the placement of sutures in a blind fashion; however, this mechanism is tolerated well by the heart, and the operator has sufficient time to evaluate the lesion and close it in a comparatively leisurely fashion.

DIVERSION OF BLOOD FROM THE HEART AND CLOSURE OF THE DEFECT UNDER DIRECT VISION. Methods are rapidly evolving by which blood flow can be diverted com-

pletely away from the heart and the blood reoxygenated by an artificial heart-lung machine. This permits the surgeon to open the heart, evaluate the defect under direct vision, and to repair the defect. Several types of pump oxygenators have been devised and used successfully. By using such methods, atrial septal defects have been closed by direct suture or by inserting patches of various materials such as Ivalon sponge. This technique appears to be the most promising method for the operative management of atrial septal defects as well as of many other cardiac anomalies.

MITRAL STENOSIS

General Considerations

Although considerable experimental work was carried out and several patients were operated on for the correction of mitral stenosis in the 1920's, it was not until the 1940's that techniques were devised by which the stenosed valve could be enlarged either by dilatation and fracture of the valve by a finger inserted into the heart, or by actual cutting of the stenosed valve with a sharp instrument. Considerable impetus was given to the development of intracardiac surgery by the experience of Harken in removing foreign bodies from inside the heart and great vessels on a large number of patients during World War II. Since 1945 many thousands of patients have been operated upon successfully for the correction of mitral stenosis, and the indications for operation as well as the operative technique are fairly well standardized. Recent improvements in pump oxygenation techniques have made it possible to open the heart with a dry field and approach the diseased valves directly.

The most favorable type of patient for this operation is the younger person with mitral stenosis in whom there is no associated mitral regurgitation and whose mitral valve leaflets and chordae tendineae have retained their elasticity. However, many patients with much less favorable valvular pathology, as well as those in the older age group, may show great improvement in symptoms after operation.

Harken and Ellis have listed seven factors that influence the outcome of operation adversely, although they do not contraindicate operation necessarily. These are (1) age over forty; (2) atrial fibrillation; (3) associated aortic valve disease; (4) associated valvular insufficiency; (5) preoperative valve size of more than 1 square cm.; (6) postoperative valve size less than 2.5 square cm.; (7) calcification of the valve.

With the passage of time the inadequacy of simple dilatation and/or splitting of the fused commissures has become more apparent. According to Harken, more than 50 per cent of cases have some degree of fusion of the chordae tendineae with some "secondary stenosis" as well as the primary stenosis of the valve leaflets. This must be corrected if a good result is to be obtained.

In the future it may be that mitral stenosis can best be corrected under direct vision, using complete cardiac by-pass.

Technique of Operation (Harken) (Figs. 318 to 323)

Endotracheal anesthesia is used. The patient is placed in the lateral position with the left side uppermost. A classic left periscapular incision is used and the pleural space entered through the fourth or fifth intercostal space without removal of a rib.

An anterior incision with the patient lying on his back and the left side slightly elevated may be used.

The lung is retracted posteriorly and the pericardium opened in a vertical plane posterior and parallel to the phrenic nerve to the level of the pulmonary artery above, and downward over the superior portion of the left ventricle below. Stay sutures are placed in the two pericardial flaps for retraction and stabilization. The heart chambers and great vessels are then palpated and their size and consistency noted, as well as the presence or absence of thrills over the valvular area. Palpation of the left atrial appendage must be gentle because of the hazard of possible dislodgment of a contained thrombus. In some instances tapes may be placed around the innominate artery and left common carotid artery to be temporarily occluded during intracardiac manipulation.

Two purse-string sutures of medium heavy silk are placed in an opposing fashion around the base of the appendage, taking small bites of the myocardium, but not penetrating the endocardial layer. Care must be taken not to injure the circumflex coronary artery. These sutures permit control of bleeding once the finger has been inserted into the appendage and provide insurance should the appendage wall be torn. A curved noncrushing clamp having a serrated grip which will not slip from the smooth atrial myocardium is next applied to the wall of the atrium, excluding the appendage.

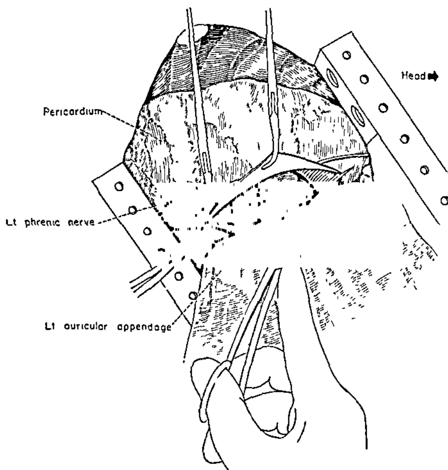


FIGURE 318 Mitral commissurotomy. The patient is in the left lateral position, the head to the right, feet to the left. The pleura has been entered through the fifth intercostal space and the lung retracted posteriorly. An opening is being made in the pericardium posterior and parallel to the left phrenic nerve (Rodriguez: Atlas of Cardiac Surgery.)

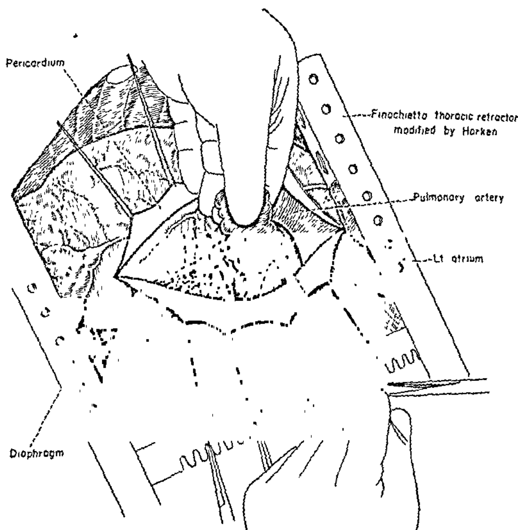


FIGURE 319. *Mitral commissurotomy (continued).* After the nature and extent of disease have been determined, double, opposing, hemostatic purse-string sutures are placed just proximal to the base of the left auricular appendage, taking care not to injure the circumflex coronary artery. (Rodriguez: Atlas of Cardiac Surgery.)

In this fashion any thrombi which may be present in the appendage are excluded from the atrium. It is not necessary to close the clamp sufficiently to lock the ratchets. The appendage is then opened sufficiently to admit the right index finger. It is then explored for possible thrombi and flushed out with saline solution to remove any loose debris. Any trabeculae which may traverse the lumen of the appendage are divided. The atrial clamp is then momentarily relaxed to allow blood to surge out of the appendage as an insurance against dislodgment of any thrombi present. The index finger is then inserted with the palm toward the diaphragm, the atrial clamp removed and hemostasis controlled with the previously placed purse-string sutures if necessary. By palpation, the size and nature of the stenosed orifice, as well as the condition of the commissures and leaflets and the absence or presence of regurgitation, are determined.

The tip of the finger with its palmar surface facing the region of the anterior lateral commissure is then introduced, making constant pressure upward in the region of the anterior lateral commissure. In favorable cases the commissure can thus be split anteriorly. The posterior fusion bridge is then divided by similar pressure. Ideally, the valve orifice should then accommodate two fingers. It is then possible to insert the finger downward through the valve and gently free the chordae tendineae, which may be adherent to each other or to the myocardial wall. The finger must be

withdrawn from the valvular area every four or five seconds to permit restoration of normal hemodynamics.

In a certain percentage of cases this "finger fracture" valvuloplasty cannot be done with gentle pressure. Further force should not be used lest serious rupture of one of the leaflets or myocardium occur. In such instances the commissure is divided with a suitable knife. The special commissurotomy knife is introduced along the surface of the index finger and the fused commissure divided. It may then be possible to enlarge the opening by gentle finger pressure, or further sharp division may be indicated. When the valvuloplasty has been completed, the finger is withdrawn and the previously placed purse-string sutures tied.

The redundant portion of the appendage is amputated and saved for histologic examination. The stump of the appendage is then oversewn with arterial silk. The

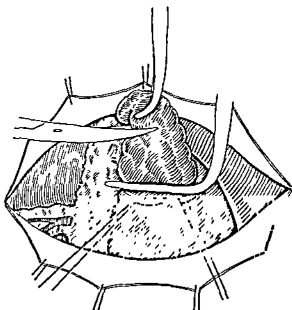


FIGURE 320. Mitral commissurotomy (*continued*). A noncrushing vascular clamp is placed just below the base of the auricular appendage, and an incision just large enough to admit the right index finger is made in the tip of the appendage. (Rodriguez: Atlas of Cardiac Surgery.)

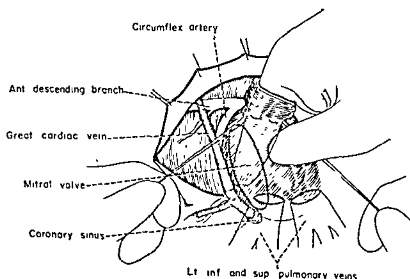


FIGURE 321. Mitral commissurotomy (*continued*). When the inside of the appendage has been examined for possible thrombi and flushed out with saline solution, the right index finger is inserted into the left atrium and the status of the valve rapidly assessed. Fracture of the antero[illegible]

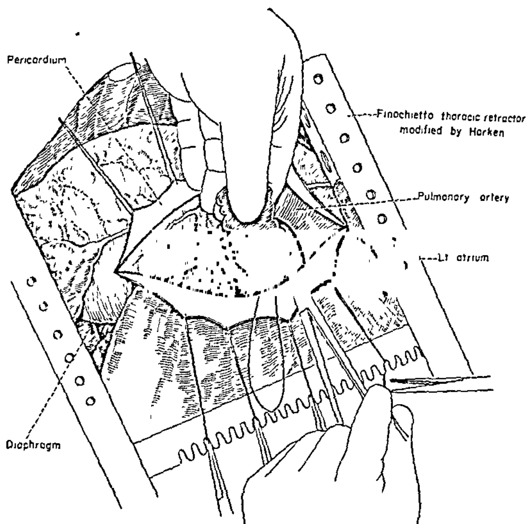


FIGURE 319. Mitral commissurotomy (*continued*). After the nature and extent of disease have been determined, double, opposing, hemostatic purse-string sutures are placed just proximal to the base of the left auricular appendage, taking care not to injure the circumflex coronary artery. (Rodriguez: Atlas of Cardiac Surgery)

In this fashion any thrombi which may be present in the appendage are excluded from the atrium. It is not necessary to close the clamp sufficiently to lock the ratchets. The appendage is then opened sufficiently to admit the right index finger. It is then explored for possible thrombi and flushed out with saline solution to remove any loose debris. Any trabeculae which may traverse the lumen of the appendage are divided. The atrial clamp is then momentarily relaxed to allow blood to surge out of the appendage as an insurance against dislodgment of any thrombi present. The index finger is then inserted with the palm toward the diaphragm, the atrial clamp removed and hemostasis controlled with the previously placed purse-string sutures if necessary. By palpation, the size and nature of the stenosed orifice, as well as the condition of the commissures and leaflets and the absence or presence of regurgitation, are determined.

The tip of the finger with its palmar surface facing the region of the anterior lateral commissure is then introduced, making constant pressure upward in the region of the anterior lateral commissure. In favorable cases the commissure can thus be split anteriorly. The posterior fusion bridge is then divided by similar pressure. Ideally, the valve orifice should then accommodate two fingers. It is then possible to insert the finger downward through the valve and gently free the chordae tendineae, which may be adherent to each other or to the myocardial wall. The finger must be

withdrawn from the valvular area every four or five seconds to permit restoration of normal hemodynamics.

In a certain percentage of cases this "finger fracture" valvuloplasty cannot be done with gentle pressure. Further force should not be used lest serious rupture of one of the leaflets or myocardium occur. In such instances the commissure is divided with a suitable knife. The special commissurotomy knife is introduced along the surface of the index finger and the fused commissure divided. It may then be possible to enlarge the opening by gentle finger pressure, or further sharp division may be indicated. When the valvuloplasty has been completed, the finger is withdrawn and the previously placed purse-string sutures tied.

The redundant portion of the appendage is amputated and saved for histologic examination. The stump of the appendage is then oversewn with arterial silk. The

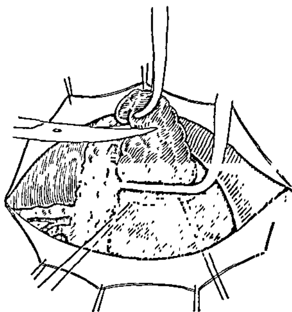


FIGURE 320. Mitral commissurotomy (*continued*). A noncrushing vascular clamp is placed just below the base of the auricular appendage, and an incision just large enough to admit the right index finger is made in the tip of the appendage. (Rodriguez: Atlas of Cardiac Surgery)

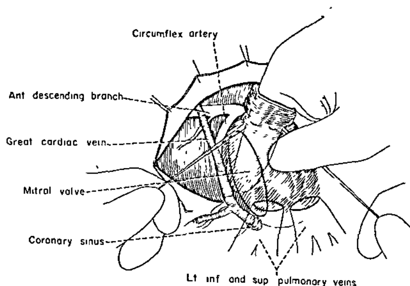


FIGURE 321. Mitral commissurotomy (*continued*). When the inside of the appendage has been examined for possible thrombi and flushed out with saline solution, the right index finger is inserted into the left atrium and the status of the valve rapidly assessed Fracture of the anterolateral commissure [illegible] may be applied by placing [illegible] by gentle traction on the

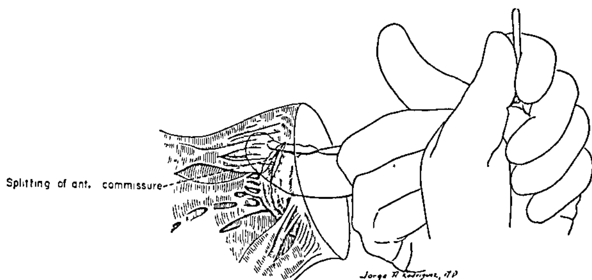


FIGURE 322 Mitral commissurotomy (*continued*). When the commissure cannot be split without exerting undue pressure, it may be necessary to cut the thickened cusp margin with a special knife slipped along the palmar surface with the finger, as indicated When the margin is divided, the remainder of the commissure as a rule splits easily with moderate finger pressure. (Rodriguez: Atlas of Cardiac Surgery.)

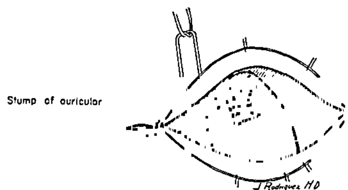


FIGURE 323. Mitral commissurotomy (*concluded*). When the valve has been opened properly, the finger is withdrawn and the purse-string sutures tied. The excess portion of the auricular appendage is removed and the opening closed with an over-and-over suture The pericardium is partially closed, leaving ample room for drainage. (Rodriquez: Atlas of Cardiac Surgery.)

heart and pericardial sac are then flushed with saline solution. If the pericardium is to be closed, a generous opening must be left for drainage into the pleural space and to prevent pericardial effusion. A tube is placed in the intercostal space for drainage and attached to a waterseal trap. A small portion of the lung at the tip of the lingula is taken for biopsy. The lung is re-expanded and the chest wall closed in layers.

Limited ambulation is usually begun from the third to the sixth postoperative day. The return to normal activity must be gradual. Patients should remain inactive for approximately six weeks and not return to full activity for approximately six months. Because of the increased work load on the left ventricle, digitalis should be continued postoperatively and a low salt diet maintained. Diuretics may be indicated in the early postoperative phase.

BECK'S OPERATION [illegible] ASCULAR[illegible] [illegible]F THE HEART

General Considerations

Although great strides [illegible] [illegible]e in the [illegible] [illegible] con-genital heart disease, and to a [illegible] the [illegible] infl[illegible] dis-

cases of the heart, attempts to improve the diminished myocardial blood supply resulting from coronary arteriosclerosis have in general yielded much less satisfactory results. Many investigators have contributed experimental and clinical observations in this field. Since 1932 Dr. Claude S. Beck has been interested in the development of a new cardiac blood supply in cases of coronary sclerosis and angina pectoris, both by anastomosis of blood vessels into the coronary vascular system and by the production of an inflammatory reaction around the heart and pericardium with resultant increased collateral circulation to the myocardium. Although this work is still in the experimental stage, it offers some hope that an operative procedure may be developed for the treatment of coronary disease which will give relief from pain and prolong life without a prohibitive mortality rate. According to Beck, any patient in whom the diagnosis of coronary artery disease is established is a candidate for operation, provided the disease has not advanced to the point at which the risk of operation is too great.

Technique of Operation (Figs. 324 to 327)

Endotracheal anesthesia, using nitrous oxide, oxygen and curare, is used. A small amount of ether may be given for supplemental anesthesia. Digitoxin, 0.1 mg., is given just before the patient is moved to the operating room, and desacetyllanatoside-C, 0.2 mg., is given intravenously if the heart rate is over 110 beats a minute.

The patient is placed on his right side for left lateral thoracotomy. If the blood pressure falls below 90 mm. of mercury and remains below this level, the operation is not started.

An incision is made over the sixth intercostal space from the nipple line in front and extending to the paravertebral muscles behind. The chest is then opened through the sixth intercostal space without removal of a rib. The ribs are spread with a self-retaining retractor and the pericardium exposed. The pericardium is then opened by an incision from the apex to the base about 4 cm. to the right of the left phrenic nerve. A second incision is made parallel to the first incision, but to the left of the left phrenic nerve, and a third incision splits the pericardium at a right angle down to the coronary sinus. Traction sutures are applied to the cut edges of the pericardium. The myocardium and coronary vessels are then examined and the presence and nature of any possible infarct observed. The lining of the parietal pericardium is then abraded throughout with special burs. Two tenths of a gram of coarsely ground asbestos is then applied to the surface of the heart.

A point is then selected between the middle and posterior veins of the ventricle, and the epicardium just below the coronary sinus is nicked with scissors. A small opening is made and the tissues gently spread by the point of a hemostat to separate the sinus from its bed A silk suture on a curved needle is then passed around the sinus, the needle passing directly into the right atrium. Care must be taken not to injure the circumflex artery, which lies in close approximation. The silk ligature is then tied around the sinus plus a 3-mm. stilet, which is removed after ligation, thus permitting only partial occlusion of the sinus. The mediastinal fat is then brought into contact with the heart over as wide an area as possible and the pericardium closed loosely. An intercostal drainage tube is passed through a stab wound and placed beneath a waterseal trap. The chest incision is then closed in layers.

Oxygen is administered postoperatively and ambulation resumed in approximately twenty-four hours.

OPERATIONS UPON THE VEINS

INTERRUPTION OF DEEP VEINS FOR THROMBOPHLEBITIS AND PHLEBOTHROMBOSIS

General Considerations

As a prophylactic measure and for treatment, interruption of the superficial femoral vein or vena cava has resulted in a reduction of the incidence of fatal pulmonary embolism. Allen reports a series of 1060 patients treated by therapeutic femoral vein interruption with five deaths, and a series of 458 patients treated by prophylactic interruption of the femoral vein with one death. Morton and his associates state that they do not ligate veins of patients who do not show either thrombosis or embolism, because they consider it too radical surgery. Robinson and Moyer point out that three fourths of patients who have common femoral vein ligation undergo undesirable postoperative sequelae and that similar sequelae develop in only 10 per cent of patients having superficial femoral vein ligation.

In ascending thrombosis, ligation of the vena cava may be indicated. Such a ligation will prevent embolism from the large pelvic vessels.

Interruption of the femoral veins or vena cava in cases of thrombophlebitis undoubtedly disturbs the venous return from the legs. Allen states that interruption of the normal femoral vein caused practically no sequelae of any importance. Thebaut and Ward noted that a majority of their patients had a mild degree of dependent edema of the lower extremities for several months after ligation of the vena cava. Shea and Robertson in a long-term follow-up of twenty-five patients having vena cava ligation found undesirable sequelae in all but one patient. Further experience is necessary before final judgment can be passed upon the late results of these operations.

Technique of Femoral Vein Interruption (Allen) (Fig. 328)

The patient is placed on the table with the upper part of the body slightly elevated. Local anesthesia is advised. A vertical incision 8 cm. long is made from the crease in the groin downward over the deep vessels. The pulsating femoral artery is used as a guide. Dissection is made parallel to the vessels to avoid lateral division of tissues. The vein is usually found medial to the artery, but may lie almost completely beneath it. The artery should be freed only enough to permit lateral retraction. Injury to a calcareous artery might result in thrombosis and gangrene.

The segment of the vein to be divided lies in the center of the wound as described. The bifurcation in the femoral vein is located by the bulge at the upper end of the superficial femoral. Ligatures are passed about the vein for traction and fixation. The anterior half of the vein is divided transversely between the untied ligatures. If a clot is present, it will appear in the vein and can be removed from the upper segment with forceps or by gentle suction. After bleeding is free from the upper segment as much clot as possible is removed from the lower segment The ligatures are then tied, and the vein is completely divided. Transfixion ligatures are placed on each end of the divided

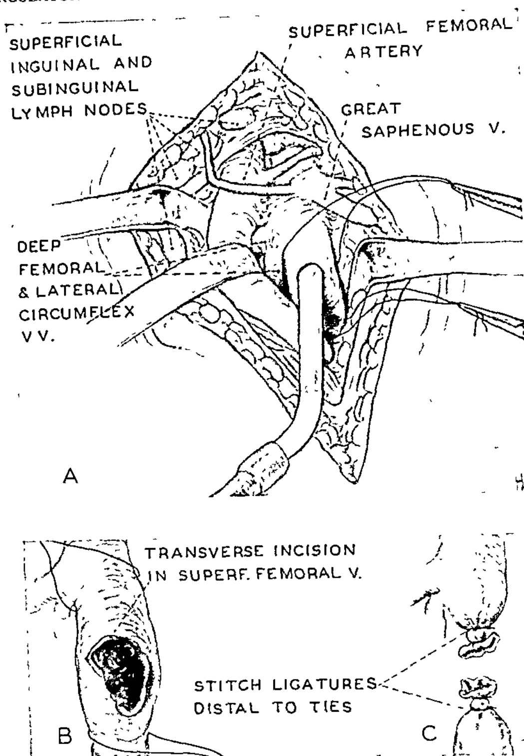


FIGURE 328 Technique of exploration and ligation of femoral vein. *A*, Clot being removed from vein by suction. *B*, Vein exposed and bleeding controlled with traction ligatures. Transverse incision in vein exposing clot *C*, Femoral vein doubly ligated and divided. (Redrawn from Allen, Linton and Donaldson: J.A.M.A , Vol. 128.)

vein. The wound is irrigated with saline solution and carefully closed in layers with fine cotton sutures.

Technique of Ligation of the Vena Cava (Fig. 329)

The vena cava may be exposed through either a transperitoneal or extraperitoneal incision. The latter is here described since it is the choice unless the ovarian veins are also to be ligated.

A transverse incision at the level of the umbilicus is made from the midrectus laterally to a point above the anterior superior spine. The anterior sheath of the rectus is divided, and the incision is extended laterally by splitting the fibers of the external oblique, the internal oblique, and transversalis muscles. The tenth and eleventh intercostal nerves are protected. By blunt dissection the peritoneum is raised posteriorly and medially and retracted to expose the vena cava. The ureter is identified and retracted medially. The iliopsoas muscle, genitofemoral nerve and right sympathetic nerve chain should be identified. At the level of the bifurcation of the aorta the vena cava is freed by blunt dissection. Tributary segmental veins should not be torn. The vena cava is ligated with two umbilical tapes placed about 1 cm. apart. If there is doubt about the existence of a thrombus within the vein, it may be opened between the untied ligatures, and the clots may be removed by suction. To add security, transfixion ligatures of silk may be placed between the tape ligatures. The use of catgut for ligature material has been advocated with the idea that revascularization will occur and eliminate some of the undesirable late sequelae. The right lumbar sympathetic chain may be excised if desired.

After controlling all bleeding carefully, the retracted peritoneum is replaced, and the abdominal wound is closed in layers with interrupted sutures of cotton or silk.

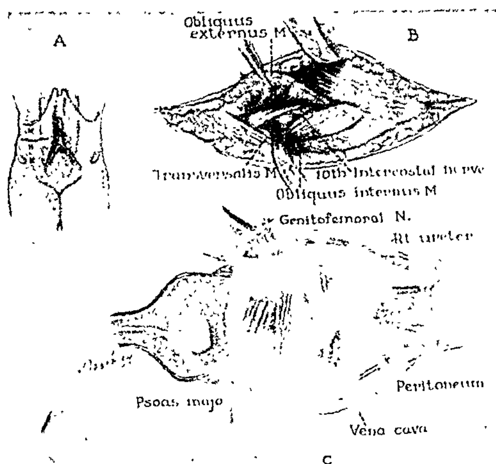


FIGURE 329. T the level of the umbil muscles are s ted medially 'on of the a rmission o tion of the rior sheath heir fibers The vena point o ogy a cava A, muscle is neum l ligate t a e incision is made at d the lateral abdomi- ed by blunt dissection bilical tapes opposite rg , Gynec. & Obst ,

This operation, when done at the proper time, will reduce the incidence of pulmonary embolism. Additional experience with the technique is needed to determine the extent of undesirable complications which may result from interrupting the vena cava.

TREATMENT OF VARICOSE VEINS

General Considerations

Varicosities of the saphenous veins are among man's most common afflictions and were among the first conditions treated by surgical means. During the modern surgical era the preferred method of treatment of varicose veins has gone through several phases and revolutions. After the development of the hypodermic syringe attempts to produce obliteration of the dilated veins by the injection of sclerosing solution of various types were made with moderate success for many years. The various ligation techniques were practiced for many years, and around the turn of the century the combination of ligation and injection of sclerosing solutions was introduced. Until the middle 1940's the technique of high saphenous ligation combined with the retrograde injection of sclerosing solution was the method most widely in use. In the late 1940's the procedure of high ligation of the saphenous vein and its tributaries in the fossa ovalis combined with stripping of the varicosities from the ankle to the groin was reintroduced and is now used almost exclusively. Various stripping techniques using both the intraluminal and extraluminal types of strippers were introduced in the early 1900's, as was the practice of stripping the entire vein through an incision carried from groin to foot.

However, because of the morbidity associated with such procedures as well as the high incidence of wound infection due to the large areas exposed, stripping techniques were not widely used. With the availability of antimicrobial drugs as well as a better understanding of methods of skin preparation, the occurrence of wound infections became of much less serious import.

Many different types of intraluminal vein strippers are now available. They are all identical in principle, varying only in minor details.

Dangers and Safeguards

Before ligating or obliterating varicose veins, tests should be made to ensure the patency of the deep veins. The superficial veins may be the chief means of returning the blood from the extremity. A history of femoral thrombophlebitis following pregnancy, infectious disease, leg injury or operation should put one on guard.

With the *Trendelenburg test* the competency of the valves of the saphenous and communicating veins can be determined. The more elaborate comparative *tourniquet test of Mahorner and Ochsner* (Fig. 330) gives additional information concerning the competency of the communicating veins between the deep and superficial systems and the patency of the deep veins.

Wound infection, or infection following ligation or vein stripping, is unusual if the skin is prepared properly as for any surgical operation. The area about leg ulcers is frequently infected and should be treated before operation is done. Sclerosing solutions injected into the subcutaneous tissues may cause violent reaction or sloughing.

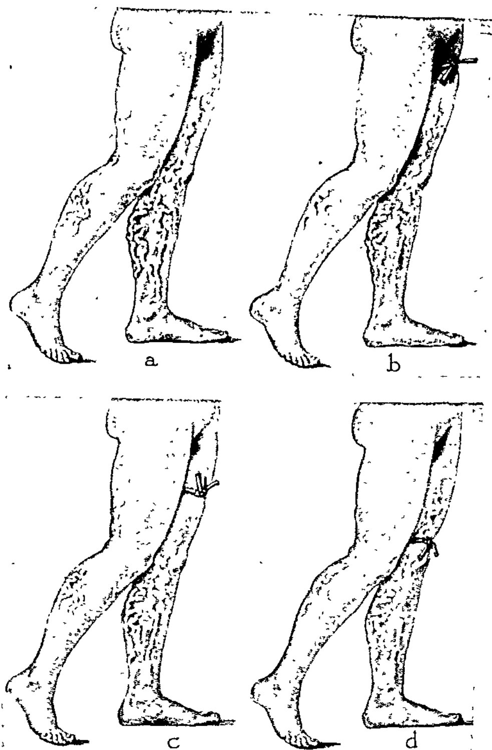


FIGURE 330 Drawings illustrating performance of the comparative tourniquet test for determining the competency of the valves of the veins communicating between the deep and the superficial systems and patency of the deep veins of the leg. The patient walks at a normal gait, and the prominence of the veins of the calf is noted (*a*). Thereafter the tourniquet is applied to the upper thigh (*b*), sufficiently tight to compress the superficial veins. Observations are made for comparative changes in the appearance of the veins of the calf The tourniquet is likewise applied to the middle and the lower third of the thigh (*c*) and (*d*) The patient walks over the same course, and the prominence of the veins is noted. If the deep and communicating veins of the thigh are patent, there is diminished prominence of the veins of the calf when the patient walks with the tourniquet applied If the valves of the communicating veins are incompetent when the patient walks with the tourniquet around the upper third of the thigh, there is some diminution in the prominence of the varicosities, but they do not entirely disappear because the blood spills through the incompetent communicating veins from the femoral to the long saphenous vein When the tourniquet is below the lowest communicating vein of the thigh in which the valves are incompetent (*d*), the varicosities of the calf collapse or disappear. (Mahorner and Ochsner Ann Surg , Vol. 107, J B Lippincott Company.)

Leakage of lymph from the upper thigh incision may occur rarely and delay healing for days or weeks.

Embolism is a rare complication of the vein ligation and injection treatment of varicose veins. In properly selected cases, treated by the ambulatory method, the incidence of embolism should be less than 0.5 per cent. Too much rest in bed after treatment predisposes to embolism.

Technique of High Saphenous Vein Ligation and Stripping (Figs. 331, 332)

The entire leg, groin and lower abdomen are shaved carefully on the day before operation. At the same time the entire leg is scrubbed carefully with soap or a detergent containing hexachlorophene. When there are numerous tortuous veins present, it is desirable to mark the areas of incompetent perforating veins with the patient standing. This marking can be done by placing a small scratch mark on the skin or by use of a marking solution such as pyrogallic acid in acetone and alcohol.

Spinal anesthesia is satisfactory, although, if bilateral operation is to be done, a continuous spinal may be necessary. General anesthesia may be preferred. In some instances the high ligation portion of the procedure may be done using local anesthesia and the stripping portion with the patient under general anesthesia.

The entire leg, or both legs if the bilateral procedure is to be carried out, is again prepared by scrubbing with soap or a detergent containing hexachlorophene. Draping must be done carefully, leaving the entire leg from groin to ankle exposed. The lower portion of the leg should be covered temporarily while the groin portion of the dissection is being carried out; and when bilateral operation is being done, the leg not being operated on should be covered while the opposite leg is exposed.

An oblique incision is made approximately 2 cm. below and parallel to the inguinal ligament centered over the fossa ovalis. In obese patients the position of the saphenous vein can be determined by palpating the femoral artery, which lies slightly

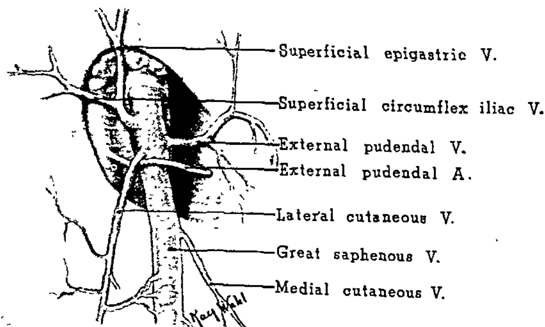


FIGURE 331 The usual anatomy of the saphenofemoral juncture and the common arrangement of tributaries in the region of the fossa ovalis. *It is important that all tributaries be ligated and divided.*

lateral to the vein. Incision should be of liberal length so that tributary veins may be divided. The dissection is carried through the subcutaneous tissue and deep layer of the superficial fascia, after which the greater saphenous vein is readily identifiable. The vein is then dissected completely and followed upward to its entrance into the common femoral vein. All tributary veins are isolated, ligated and divided. The external pudendal artery is usually ligated and divided to permit better exposure. It is important to inspect the common femoral vein both above and below the entrance of the saphenous bulb to eliminate the possibility of additional tributary veins. The vein is then ligated flush with the femoral vein, using medium silk and a transfixion suture placed distally for reinforcement. The vein is then divided and the medial and lateral cutaneous branches of the great saphenous vein exposed. The fossa ovalis is then closed with fine interrupted silk. If the operation is to be bilateral, it is better to do *the high ligation on the opposite side before doing the stripping on either side.*

It must be kept in mind that the number of tributary veins to the saphenous veins may vary greatly, and it is important that all tributaries be traced out, ligated and divided to prevent re-formation of the saphenous channel.

When the high ligation has been completed, the intraluminal stripper is introduced into the vein. The stripper may be introduced downward from the groin, upward from the dorsal vein of the foot to the groin, or may be passed both ways from the knee level. The ease with which the stripper can be introduced will vary, depending upon the individual case. The vein is then tied to the stripper with heavy silk proximal to the acorn tip. It is often helpful to leave a long piece of silk tied to the

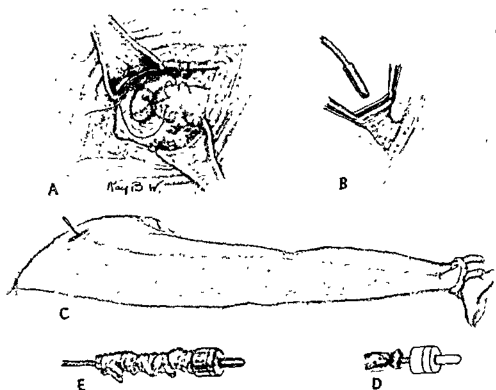


FIGURE 332. High ligation and stripping of saphenous vein *A*, The saphenous vein and all tributaries are ligated and divided at the saphenofemoral juncture. *B*, Introduction of the intraluminal stripper through the end of the divided vein. *C*, The stripper is passed when possible from the groin to the ankle, where a second incision is made, and the vein is divided and secured to the stripper. *D*, Method of securing vein to the stripper. *E*, Specimen after completion of stripping, illustrating the telescoping of the vein on the stripper.

stripper so that this can follow the stripper to the groin during the stripping procedure. This is of value if the vein should break during the stripping or if the vein should shred, and enables one to find the channel in the middle of the leg with ease. During and after the stripping procedure it is of value to have the leg elevated to minimize bleeding, and pressure should be applied along the course of the stripped vein after removal.

It is important that tributary veins also be divided and stripped. These veins, which have been marked before operation, are exposed through small incisions and removed with the stripper. It may be helpful to expose the tributary veins after the stripper has been placed in the great saphenous. Several small supplementary incisions may be required for removal of the tributaries, particularly if they are numerous and tortuous. When the vein has been removed and bleeding controlled by pressure and elevation, the groin incision is closed with interrupted silk, and the small supplementary incisions are likewise closed. Care must be taken in closure to ensure optimal wound healing. Any clotted blood present in the main channel from stripping, or in the wounds, may be expressed by rolling a rolled towel along the channel. Any blood is then washed from the skin. Small gauze dressings are then applied over the channel from which the vein has been stripped and the entire leg from ankle to groin wrapped with elastic bandages. This bandage must be applied carefully to ensure the right amount of pressure, and long strips of adhesive plaster applied in a spiral fashion may be of value in preventing the elastic bandages from slipping when the patient becomes ambulatory.

Ambulation is usually begun after recovery from anesthesia. Antibiotics are used only in obese patients, those having open ulcerations or when the dissection has been extensive or difficult.

Sutures are removed in seven to ten days following operation, and any small varicosities remaining are treated by injection with sclerosing solutions. Elastic bandages at least to knee level are kept on for six to eight weeks after operation.

Technique of Simple Injection Treatment

Simple injection treatment is indicated only when varicosities are minimal. It is also used after the stripping technique to produce sclerosis of any small remaining varicosities. The patient should be standing or sitting so that the veins will be distended. A 5-or 10-cc. syringe with a small needle is used. A 5 per cent solution of sodium morrhuate, a 5 per cent solution of sodium gynocardate or a 50 per cent solution of dextrose is a satisfactory sclerosing agent.

The needle is introduced into the vein and blood withdrawn to be sure that the point of the needle is in the lumen. Necrosis may result if the solution is injected into the perivascular tissues. With the index finger of the left hand the vein is compressed 2 to 3 cm. above the needle. The reverse flow of the blood empties the vein below the needle to isolate a segment of vein 4 to 5 cm. long to be injected. The quantity of solution injected is usually 2 or 3 cc. of 5 per cent sodium morrhuate, 2 or 3 cc. of sodium gynocardate or 5 to 10 cc. of 50 per cent dextrose. The needle is left in place for a few moments and then withdrawn as the opening is lightly compressed with gauze to prevent leakage. The compressing fingers release the vein in a minute or two, and a compression pad is applied to be held in place with adhesive plaster.

Two or three injections may be made at one treatment, to be repeated when necessary in four or five days, unless the reaction has been too severe.

Mahorner and Ochsner report recurrences in 60 per cent of patients treated by simple injections. They advise the ligation and injection treatment when there are no contraindications.

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CHAPTER 12

Abdominal Incisions

General Considerations

Incisions for operations upon the abdominal contents should be planned to meet the following requirements: (1) ample exposure of the part to be operated upon; (2) minimum of damage to the structures of the abdominal wall; (3) ease of closure; (4) closure with minimum tension on the suture line; (5) firm healing to prevent disruption or incisional hernia; (6) minimal postoperative adhesions beneath the scar; (7) minimum of postoperative pain; (8) shortening of convalescence.

The paramedian incision with retraction of the muscle laterally is anatomic and does not destroy the nerve or blood supply to the rectus muscle. A *transrectus incision* through the inner margin of the rectus muscle is commonly made and infrequently causes abdominal wall weakness Incisions through or near the linea semilunaris injure the nerve supply to the rectus muscle and should be avoided when possible. A possible exception to this rule is the *Battle incision,* which is short and in which not more than one nerve segment is damaged (Fig. 343). McGregor states that one or even two of the nerves of the rectus muscle may be divided without weakening the abdominal wall, but advises against taking such risk.

Incisions directly in the linea alba make a weaker closure than the paramedian incision and have no advantage over the latter.

Oblique incisions through the abdominal wall which split the fibers of the external oblique muscle and sever the internal oblique and transversalis muscles are satisfactory. Such an incision parallels the main trunks of the intercostal nerves. Transverse abdominal incisions give adequate exposures, permit firm closures with few disruptions, and cause a minimum of postoperative discomfort.

ABDOMINAL WOUND CLOSURE

Abdominal wounds are usually closed in layers. The peritoneum and posterior sheath of the rectus muscle are sutured together. Below the semilunar fold of Douglas the peritoneum is closed as a separate layer. Lateral to the margin of the rectus, the peritoneum may be sutured as a separate layer or with the transversalis muscle.

The use of catgut, silk, cotton or alloy steel wire depends upon the choice of the surgeon. Each of these suture materials has strong advocates, and undoubtedly each has merit which not all possess. Buried sutures of silk, cotton or wire should be interrupted. Occasionally infections or granulomas may form about nonabsorbable sutures which will necessitate their removal.

Whipple and Elliott prefer fine silk for closure of clean abdominal wounds. When catgut is used, no. 00 chromic is the choice. They close the peritoneum and posterior rectus sheath with a continuous fine silk suture reinforced every 2 cm. with an interrupted silk suture. The same suture material is used in the anterior rectus sheath placed 7 to 8 mm. apart as "far and near" stitches (Fig. 333). The near stitch is placed through the margin of the fascia and the far stitch about 5 mm. from the margin. The stitches are tied loosely to allow for the increased tension produced by the edema of repair. Whipple and Elliott emphasize the importance of preventing the protrusion of omental tags through the sutured posterior sheath and the virtue of the tensionless suture to prevent tissue necrosis. The skin is closed with interrupted fine silk sutures. Retention sutures are not used.

For closure of high rectus incisions, Clute has recommended the use of mattress sutures to include the peritoneum, transversalis muscle and fascia (Fig. 345). This suture line is reinforced with a continuous suture. These sutures protect against the strain of the transversalis pull in postoperative vomiting and moving. The portion of the peritoneum and fascia below the transversalis muscle is closed with a continuous suture.

Eversion of the peritoneal and posterior fascia wound margin is desirable to minimize adhesions. This may be done with interrupted or continuous mattress sutures. If a continuous mattress suture is used, a "switch-back" stitch taken every third suture will make the closure more secure and prevent spreading of the wound as the suturing progresses (Fig. 340). Herniation of omentum between the sutures must be prevented. If the muscle is split, it may be approximated with three or four loosely tied interrupted sutures, or left without stitches if through-and-through retention sutures are to be used. The anterior rectus sheath is closed with interrupted or continuous sutures. Margins of the fascia are carefully approximated so that muscle cannot protrude between the stitches to prevent firm union. The skin is closed with

interrupted "on-end" or vertical mattress sutures or with a continuous suture of the same type with added lockstitch (Fig. 340).

A few surgeons have recommended through-and-through sutures of silkworm gut or *silver wire* to include all layers of the abdominal wall as preferable to the layer

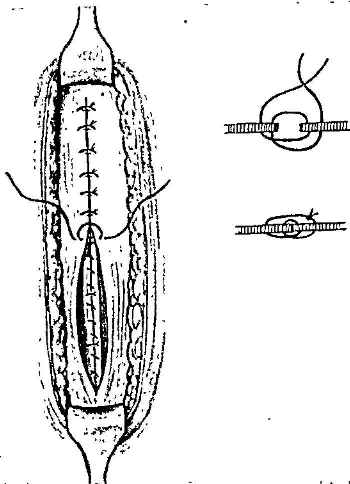


FIGURE 333. Method of closure of anterior rectus sheath with "far-and-near" interrupted sutures of fine silk (Redrawn from Whipple and Elliott)

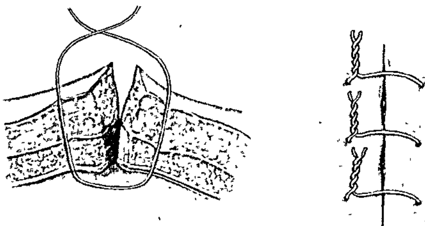


FIGURE 334. Through-and-through silver wire closure of contaminated abdominal wounds. This method avoids the foreign bodies of the sutures in the wound and disturbs the blood supply much less than the usual layer closure. (Redrawn from Reid: South. M J.)

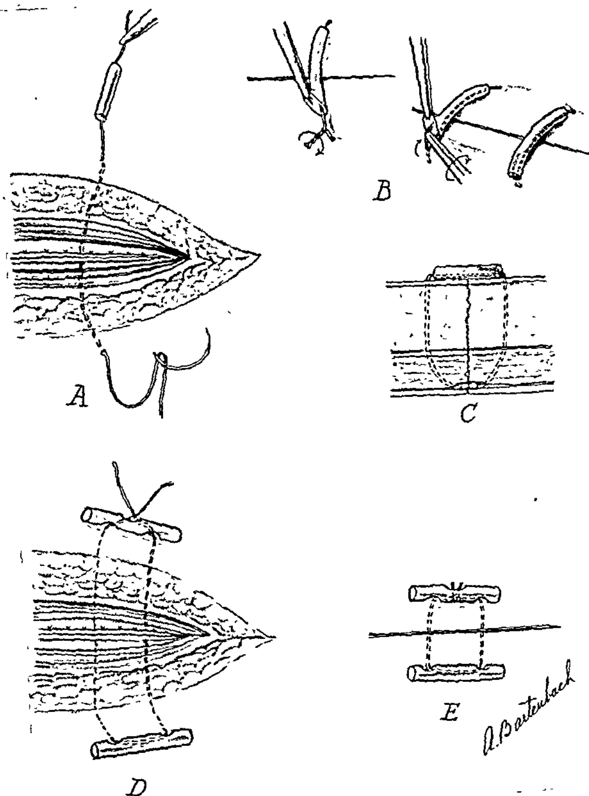


FIGURE 335 Deep through-and-through sutures *A*, Silver wire suture placed through entire thickness of abdominal wall, picking up the everted margins of the posterior sheath of the rectus *B*, Details of sheathing cut ends of silver wire in rubber tubing guard. *C*, Cross section of silver wire through-and-through suture in place *D*, Mattress through-and-through suture using silk or silkworm gut The rubber tube guards are fenestrated to prevent folding of tubing. *E*, Deep mattress suture in place.

closure of abdominal wounds. Reid recommends such sutures of silver wire for grossly contaminated wounds. Through-and-through silver wire sutures are especially suitable for the closure of disrupted wounds (Fig. 334).

Retention sutures of silkworm gut, silk or cotton may be placed as through-and-through single sutures or as mattress sutures. Silver wire is an excellent material for single through-and-through sutures. As the suture is placed, it should be passed through the everted margin of the posterior rectus sheath (Fig. 335). To prevent necrosis, these sutures should not be tied tightly.

Technique of Wound Closure with Stainless Steel Wire

The value of alloy stainless steel wire as a suture material has been emphasized in recent years. Jones and his associates have described its use in abdominal wound closure (Fig. 336). These authors found that the incidence of wound infection and wound disruption was much reduced by the use of steel wire. Wiley and Sugarbaker's results have been similar to those of Jones. The latter authors believe that steel wire

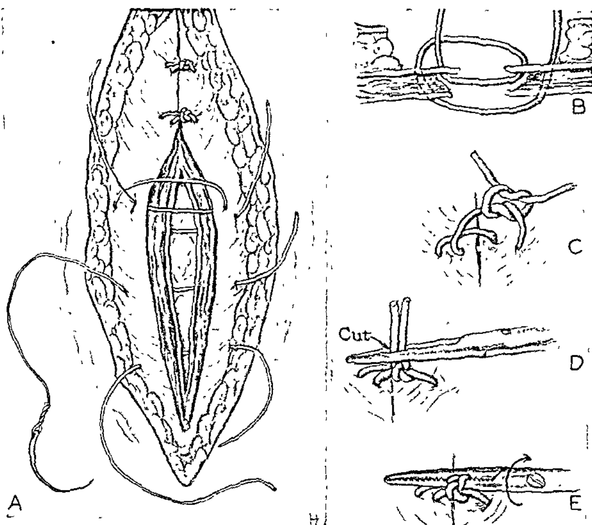


FIGURE 336. [illegible] sutures through-an[illegible] suture is clamped [illegible] against the knot and severed against the hemostat with scissors or wire cutters. *E*, The cut ends are turned down. (Redrawn from Jones, Newell and Brubaker: Surg., Gynec & Obst.) [illegible] a square knot. *D*, The

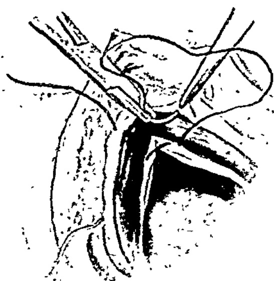


FIGURE 337. Technique of wound closure with stainless steel wire. A figure-of-8 suture of no. 30 stainless steel wire is placed through the anterior sheath of the rectus muscle and peritoneum. (Coller and Ransom: Surg., Gynec. & Obst., Vol. 78. By permission of Surgery, Gynecology and Obstetrics.)

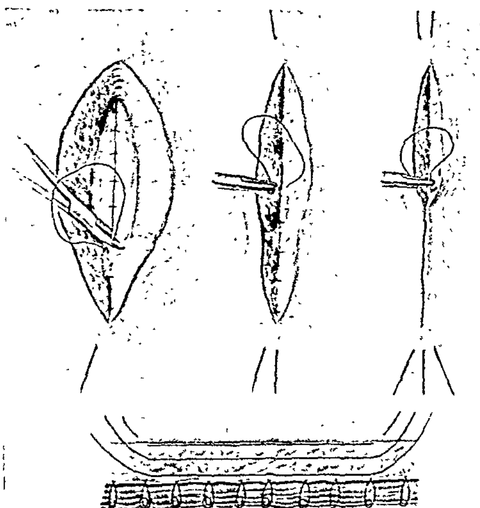


FIGURE 338 Technique of wound closure with stainless steel wire. The subcutaneous tissues of the abdominal wall are closed with one, 2 or 3 rows of wire sutures placed like the Cushing right-angled continuous intestinal suture. The ends of the wires are left long to facilitate removal after the wound has healed. (Coller and Ransom. Surg, Gynec. & Obst., Vol. 78. By permission of Surgery, Gynecology and Obstetrics.)

is preferable to catgut and silk because it produces less trauma, has maximum tensile strength during the early postoperative period, is well tolerated by the tissues, and reduces the incidence of wound infection, wound disruption and sinus formation. Jones emphasizes that, in closing a wound with wire, certain technical details must be observed. The suture must be tied under the proper tension to approximate but not to constrict the tissues, the knot must be square, and the ends of the wire must be turned down carefully. In order to make a smoother closure of the peritoneum, Wiley and Sugarbaker recommend an additional loop of the stitch placed through the peritoneum.

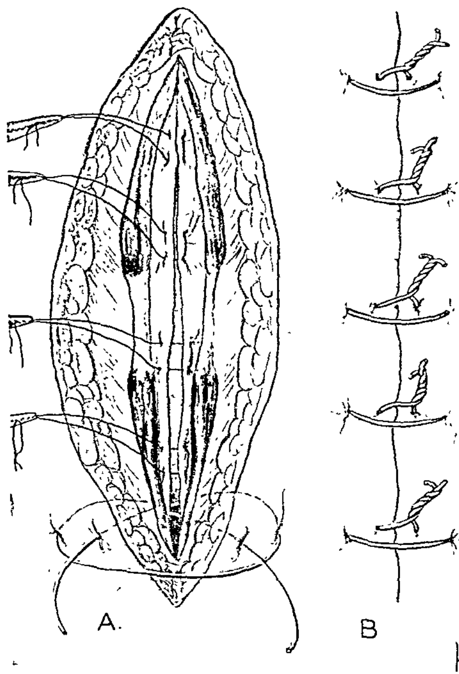


FIGURE 339. Technique of wound closure with through-and-through steel wire used as "near and far" sutures. The peritoneum and *posterior rectus sheath* are closed with mattress sutures of silk. (Redrawn from Whipple: Surg, Gynec. & Obst)

Coller and Ransom recommend a figure-of-8 suture of no. 30 stainless steel wire for abdominal wound closure (Figs. 337, 338). The subcutaneous layers of the abdominal wall are closed with one, two or three continuous wire sutures in a manner similar to the Cushing right-angled continuous intestinal suture (Fig. 338). These subcutaneous sutures are removed after the wound has healed.

Whipple has used "near and far" steel wire sutures placed through the full thickness of the abdominal wall for wound closure (Fig. 339). Before placing the wire sutures he unites the peritoneum and posterior sheath of the rectus muscle with mattress sutures of silk.

PARAMEDIAN INCISION

The paramedian type of incision is useful for both upper and lower abdominal operations. There is no danger of weakness resulting from paralysis of the muscle of the abdominal wall, since there is no injury to important nerves or vessels.

Technique (Fig. 340)

An incision of suitable length is made parallel to and about 2 cm. from the midline. The anterior sheath of the rectus muscle is exposed and incised. The inner margin of the rectus muscle is separated and retracted outward to expose the posterior rectus sheath. The posterior sheath is incised with the peritoneum directly opposite the incision in the anterior sheath. Midway between the umbilicus and the pubes, the posterior rectus sheath ends in the semilunar fold of Douglas. When a paramedian incision is made below the umbilicus, it is continued downward from this fold through the peritoneum. This incision can be made any length desired, since it does not section nerves and paralyze muscle.

This type of wound is closed in layers. The posterior sheath and peritoneum are sutured with catgut or silk. A continuous or interrupted type of mattress suture is desirable to evert the wound margins. The muscle is replaced and fixed in the gutter between the anterior and posterior sheaths with a few interrupted stitches. The anterior sheath may be closed with continuous or interrupted sutures. The skin is closed with silk.

Retention sutures of the mattress type or single interrupted deep stitches may be used (Fig. 335). When these sutures are passed through the abdominal wall, they should also be passed through the everted edges of the sutured posterior sheath to ensure stability and close dead space.

A drain may be placed through this type of incision or emerge through a stab wound near the outer margin of the rectus muscle.

MIDLINE INCISION WITH LATERAL EXTENSION

To increase exposure, especially in the upper abdomen, a transverse incision may be made through the skin and anterior and posterior sheaths of the rectus muscle at a right angle to a median incision. This type of exposure may be indicated in certain operations upon the gallbladder, stomach, pancreas, spleen and transverse colon.

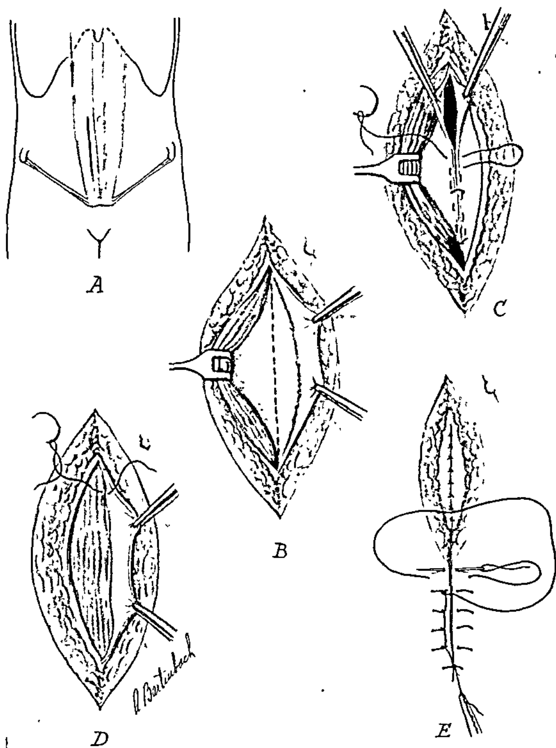


FIGURE 340. Paramedian abdominal incision. *A*, Line of skin and fascia incision over the inner third of the rectus muscle. *B*, Sheath of rectus muscle opened and rectus muscle retracted from the midline. Line of incision in the posterior rectus sheath. *C*, Closure of posterior rectus sheath and peritoneum with a continuous mattress suture to evert the wound margins. A "switch-back" stitch may be used every third stitch to prevent slipping of the continuous suture. *D*, Replacement of rectus muscle in rectus sheath gutter at midline *E*, Closure of anterior rectus sheath with interrupted sutures and closure of skin with a continuous on-end mattress lockstitch suture. If silk is used, all sutures should be interrupted except those in the skin.

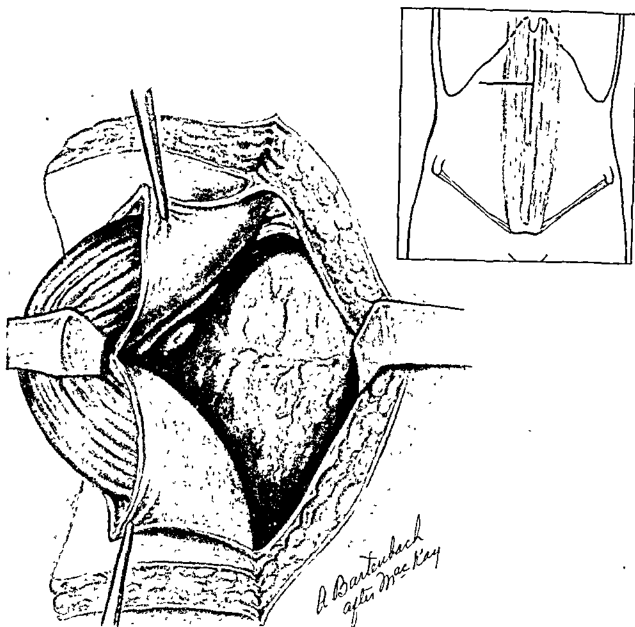


FIGURE 341 Epigastric midline incision with lateral extension To enlarge the midline incision, the skin and subcutaneous tissues have been incised at a right angle to the midline, the anterior and posterior sheaths of the rectus muscle incised transversely, and the rectus muscle retracted laterally. (Redrawn from Mayo Proc Staff Meet., Mayo Clin)

Technique (Mayo)

A median incision is made above the umbilicus. At the proper level for maximum exposure the skin is incised at a right angle to the primary incision (Fig. 341). This transverse incision is extended to the outer margin of the rectus muscle. The anterior and posterior sheaths are cut across and reflected from the rectus muscle both upward and downward to free the muscle for retraction. Exposure is obtained by strongly retracting the muscle outward. To close this incision, the posterior and anterior *sheaths of the rectus are sutured first, followed by sutures in the midline. Interrupted* sutures are preferable.

When drainage is necessary, it may be placed at the outer end of the transverse incision through a stab wound made at the lateral margin of the rectus muscle.

This type of lateral extension incision can be used to enlarge the wound of a paramedian incision described above.

TRANSRECTUS MUSCLE-SPLITTING INCISION

The transrectus muscle-splitting incision is frequently used, but has the disadvantage of nerve injury with possible paralysis and atrophy of that portion of the muscle medial to the incision. If no more than two intercostal nerves are severed and

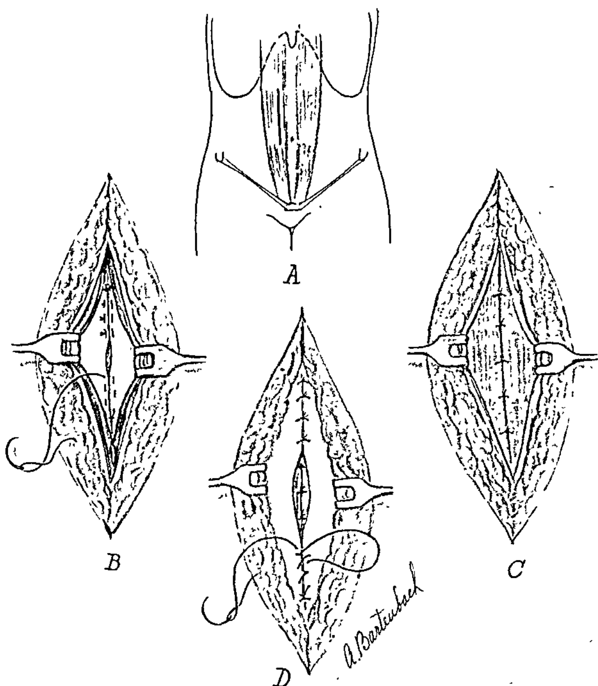


FIGURE 342. Transrectus abdominal incision *A*, Line of incision, which may be extended upward or downward This incision is made near the median line to minimize destruction of the nerve supply to the rectus muscle *B*, Divided rectus muscle with its anterior sheath retracted to show methods of suture of the posterior rectus sheath. Continuous or interrupted mattress sutures may be used to evert the wound edges *C*, A few interrupted sutures are placed to approximate the edges of the split muscle. These sutures are not advisable if through-and-through sutures are used *D*, Types of sutures used in closing the anterior sheath of the rectus muscle Interrupted sutures are shown at one end, and at the other a continuous suture with a "switch-back" every third stitch. If silk is used, all sutures should be interrupted

if the incision is near the median border of the rectus muscle, the danger of producing abdominal wall weakness is minimal. This incision may be extended laterally as described in the technique of the median incision.

Technique (Fig. 342)

The steps in the making and closing of this incision are the same as those used in the paramedian incision except that the muscle is separated in the direction of its fibers and not retracted laterally from the midline. Branches of the superior and inferior epigastric vessels are frequently severed and must be ligated to prevent the formation of hematomas behind the muscle.

The split muscle margins may be approximated with three or four loosely tied interrupted sutures, although some surgeons consider this step unnecessary. Such sutures obliterate dead space, but have little holding value. If through-and-through retention sutures are used, stitches in the muscle are never necessary.

BATTLE OR PARARECTUS INCISION

The Battle or pararectus type of incision has the disadvantage of injury to the nerve supply of the rectus muscle. If not too long, with section of only one nerve, it may be used without fear of postoperative rectus muscle weakness. It is suitable for appendectomy and may be made large enough for exploration of the pelvis. It is not as satisfactory for pelvic operations as the paramedian incision.

Technique (Fig. 343)

An incision is made about 2 or 3 cm. medial and parallel to the outer margin of the rectus muscle. The anterior sheath of the rectus muscle is incised, and the muscle is freed and retracted medially, to expose (in the lower abdomen) the semilunar fold of Douglas and peritoneum. One or two nerves with accompanying small vessels are usually exposed lying on the posterior sheath and peritoneum. If the opening into the abdomen is to be small, these nerves may be retracted upward and downward and preserved. The peritoneum is incised directly behind the anterior sheath incision.

The closure is made as in the paramedian incision. When the rectus muscle is replaced in the gutter between the anterior and posterior sheaths, it lies between the suture lines and adds strength to the closure. The margin of the rectus is held in place by three or four loosely tied interrupted stitches.

Drainage through this type of wound is not very satisfactory. A supplementary stab wound or muscle-splitting wound may be made lateral to the rectus margin if drainage is necessary.

CLUTE'S LEFT RECTUS, COSTAL MARGIN INCISION

Clute's left rectus, costal margin incision is useful to obtain adequate exposure in difficult upper abdominal operations such as resection of the stomach, total gastrectomy and repair of diaphragmatic hernias.

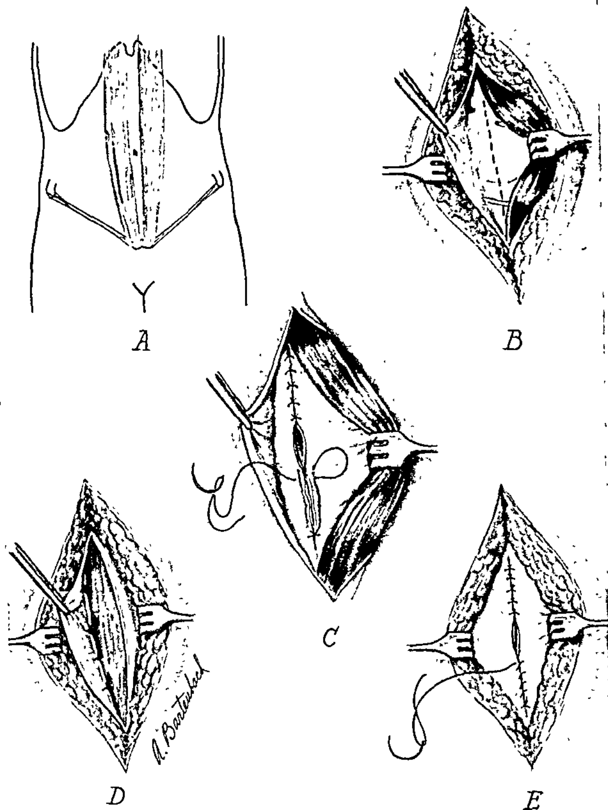


FIGURE 343 Battle incision. *A*, Line of incision over outer third of rectus muscle. *B*, Anterior sheath of rectus muscle divided, rectus muscle retracted medially, and dotted line showing line of incision in posterior rectus sheath and peritoneum. *C*, Types of sutures which may be used for closing the posterior sheath of the rectus muscle and peritoneum *D*, A few interrupted stitches are used to fix rectus muscle in its normal anatomical position *E*, Closure of anterior sheath with interrupted or continuous sutures If silk is used, all buried sutures should be interrupted.

Technique (Figs. 344, 345)

A small upper left rectus incision is made near the midline for exploration. If the lesion is operable, the incision is extended downward below the umbilicus and upward to the costal margin. At the costal margin the incision is deflected laterally at a 45-degree angle across the fused cartilages of the sixth, seventh and eighth ribs, a distance of about 5 cm. The rectus muscle is cut across obliquely or transversely, and the fused sixth and seventh costal cartilages are divided. The left hand within the abdomen locates the lower margin of the diaphragm. If the internal mammary artery is cut, it is best controlled by a suture ligature. Identification of the thick diaphragmatic muscle aids in protecting the pleura. If the pleura is opened, it must be promptly closed by moist pack or suture. *High exposure is obtained by retracting the left costal margin and by mobilizing the left lobe of the liver by cutting its lateral ligament.*

The wound is closed by suturing the anterior and posterior sheaths of the rectus muscle. No attempt is made to suture the cartilages.

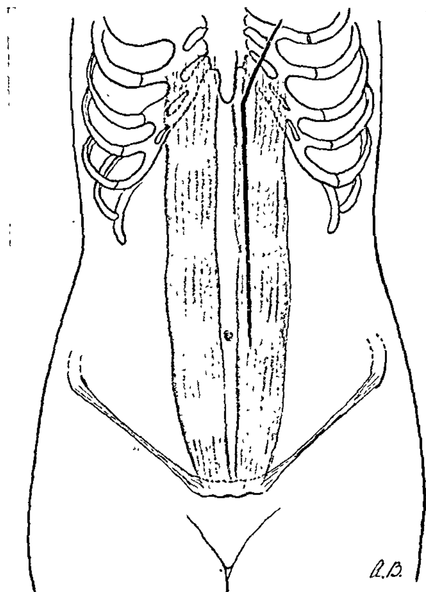


FIGURE 344 Clute's incision to increase upper abdominal exposure by cutting the costal arch The upper end of the incision turns obliquely to the left The sixth and seventh costal cartilages are divided. The incision is extended below the umbilicus (Redrawn from Clute Surg, Gynec & Obst)

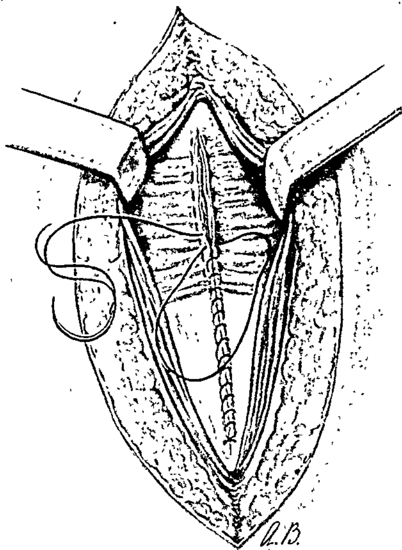


FIGURE 345. Clute's method of closing epigastric incisions. Mattress sutures are placed through the muscular portion of the transversalis. The lower portion of the peritoneum and fascia is closed with a continuous suture. A second continuous suture is being inserted through the everted edges of the transversalis and peritoneum to prevent the protrusion of omental edges between the mattress sutures. (Redrawn from Clute: S Clin. North America.)

MASON INCISION

The Mason incision can be made any length desired without damaging the nerve supply to the rectus muscles. It permits a good exposure of the upper abdominal contents.

Technique (Fig. 346)

Beginning to the left of the ensiform process, the incision extends downward parallel to the linea alba to a point 3 cm. above the umbilicus, where it curves to the right and extends 4 to 6 cm. downward to the right of the midline. The skin and superficial fascia are reflected to the right to expose the left and right sheaths of the rectus muscles About 2 to 3 cm. to the left of the midline, the sheath of the left rectus is divided the length of the skin incision It is extended to the right across the midline and downward through the sheath of the right rectus. The muscles are separated from

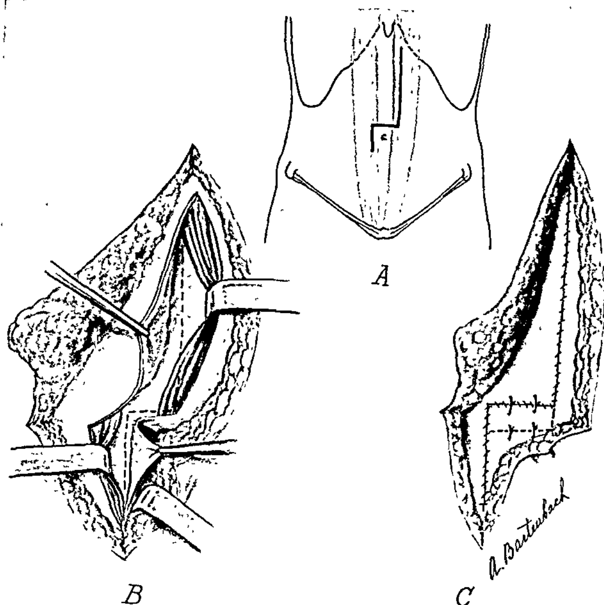


FIGURE 346. Mason abdominal incision. *A*, Line of skin incision. *B*, Anterior sheath of the left rectus, the anterior sheath of the right rectus and the fascia across the midline have been incised. The left rectus is retracted to the left and the right rectus to the right The dotted line indicates the incision to be made through the posterior sheath of the rectus muscles and across the midline above the umbilicus. *C*, Method of closure of the sheaths of the rectus muscles (Redrawn from Mason: Arch. Surg)

the midline and retracted outward on each side to expose the posterior rectus sheaths, which are incised along the line of incision in the anterior sheaths and across the midline above the umbilicus.

Closure of this wound is made in layers. An important step in the closure is the imbrication of the fascia at the transverse portion of the incision. Approximation of the fascial margins is made easier by flexing the patient on the table. Mason used continuous sutures for closing the fascia.

TRANSVERSE INCISIONS

The transverse incision is both anatomic and physiologic. It permits adequate exposure and a secure closure, and reduces to a minimum the incidence of wound disruption and postoperative hernia. Rees and Coller find that the transverse incision

reduces abdominal pain, reduces the incidence of pulmonary complications, and shortens the period of time in bed in the hospital. Gurd states that with the most extensive transverse incisions there is no danger of damaging more than one intercostal nerve. There is no risk of abdominal weakness due to nerve injury. This type of incision is somewhat more tedious to make than other types of incision and requires more time and care in closure. The advantages outweigh the disadvantages, and the extra time required for opening and closing the abdomen is relatively unimportant when the benefits of the transverse incision are considered.

The transverse incision is suitable for almost all operations within the abdomen. Vertical incisions may be made if additional exposure is needed (Gurd).

Technique of Transverse Abdominal Incision (Fig. 347)

The location of the incision must depend upon the pathologic condition to be operated upon. The incision need not extend across both rectus muscles in all cases (Fig. 348). Gurd advises that a complete transverse incision be made 2 or 2.5 cm. above or below the umbilicus. Such an incision can be extended from flank to flank, a length of approximately 50 cm. in the adult.

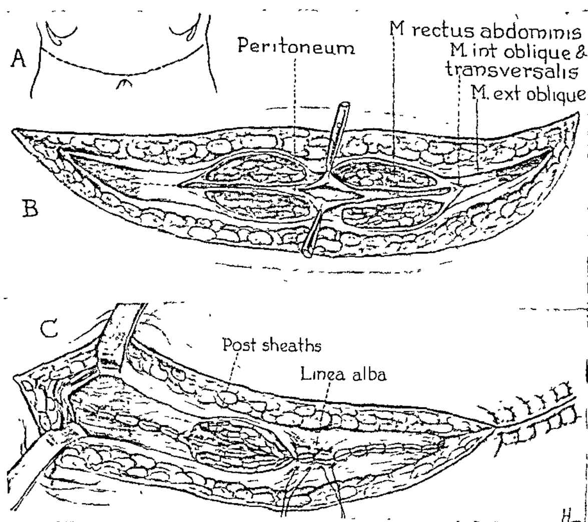


FIGURE 347. Technique of transverse incision. *A*, Location of incision above the umbilicus. A similar incision may be made below the umbilicus. *B*, All structures of the abdominal wall are divided to an extent necessary for adequate abdominal work. *C*, The posterior sheaths of the rectus muscles are closed with mattress sutures. (Redrawn from Gurd S. Clin North America)

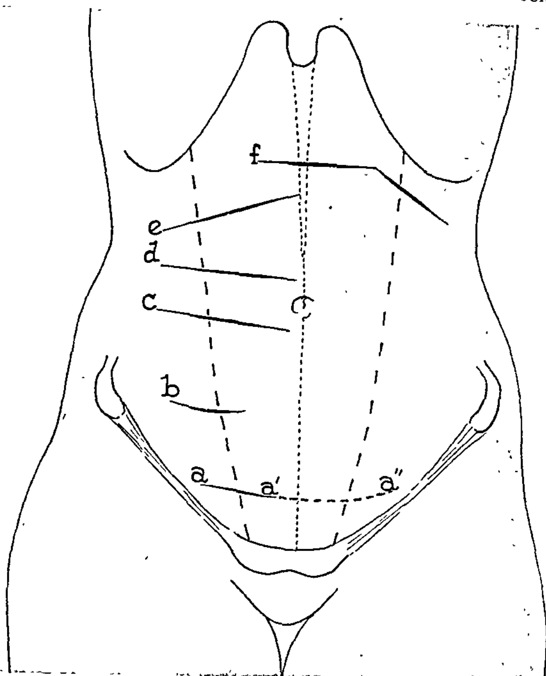
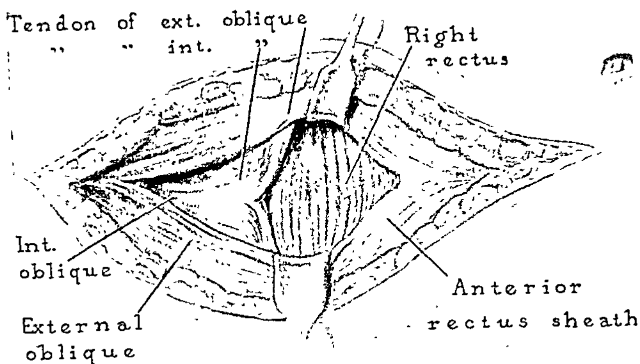


FIGURE 348 Common locations for transverse incisions. *a, a', a''*, Incisions for unilateral and bilateral herniorrhaphy; *b*, appendectomy incision; *c*, incision suitable for exploration of intestinal obstruction or, on the left, exposure of the sigmoid; *d*, incision for right colectomy; *e*, incision for biliary tract operations; *f*, incision suitable for gastric operations (Redrawn from Rees and Coller. Arch Surg)

The skin and superficial fascia are incised across the rectus muscles and a sufficient distance on each side of the rectus to afford adequate exposure. The anterior rectus sheaths and rectus muscles are cut across down to the posterior rectus sheaths. At this point all bleeding vessels should be clamped and ligated. The posterior rectus sheaths and falciform ligament are next divided (if the incision is above the umbilicus). The falciform ligament contains vessels requiring ligation. If the incision is found inadequate after exploring the abdomen, it may be lengthened at one or both ends.

For ease of closure, the head and foot of the table are raised to reduce tension on the suture line. The posterior sheaths of the rectus muscles and peritoneum are closed with mattress sutures. By everting the margins of the wound with mattress sutures, adhesions are minimized. Silk, cotton or alloy steel wire may be used. Closure may



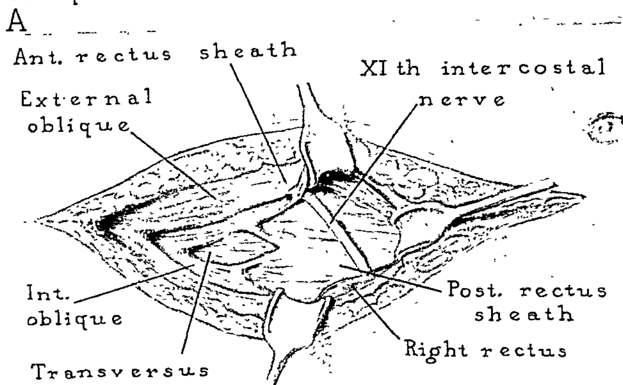


FIGURE 349. ... ansverse skin incision made about 2 cm below ... over the outer margin of the rectus muscle. ... scles are exposed. *B*, The rectus muscle is retracted medially, and the external oblique, internal oblique and transversalis muscles are divided parallel to their fibers. (Redrawn from Gurd: S. Clin. North America.)

also be made with through-and-through silver wire sutures (Fig. 334). It is not necessary to attempt suture of the cut ends of the rectus muscles. Careful closure of the rectus sheaths with interrupted sutures is sufficient to make a sound union of the rectus muscles. Muscles and fascia lateral to the rectus muscles should be closed in layers with interrupted sutures. The linea alba should be reinforced with interrupted sutures. The skin may be closed with continuous or interrupted nonabsorbable sutures. If a drain is used, it is inserted at either end of the incision.

Technique of Transverse Incision for Appendectomy (Gurd) (Fig. 349)

An incision is made from near the midline outward toward the iliac crest. This incision may be extended above the iliac crest. The rectus muscle is retracted toward the midline with the eleventh intercostal nerve. The external oblique, internal oblique, and transversalis muscles are split laterally to give sufficient exposure to explore the abdomen. The rectus muscle may be divided if necessary. The wound is closed in layers with interrupted sutures. If a drain is necessary, it should pass through the lateral end of the incision.

SLOAN TRANSVERSE INCISION

The advantages claimed for Sloan's transverse abdominal incision are ease of closure, better access to upper abdominal organs, low incidence of disruption and hernia, freedom from wound pain with ease of breathing, and less frequent pulmonary complications. It preserves the rectus muscles and does not damage the nerve or blood supply to muscles, fascia or peritoneum. The disadvantages mentioned have been the longer time required to open and close the transverse incision and lack of adequate exposure.

Technique of Transverse Abdominal Incision (Sloan) (Fig. 350)

An incision is made in the midline from the ensiform to a point 3.5 cm. above the umbilicus, where it is extended to each side of the umbilicus a distance of 4 cm. A flap of skin and fat is dissected outward, exposing the anterior sheaths of the rectus muscles. About 1 cm. lateral to the midline on each side, long incisions are made through the anterior sheaths, exposing the muscles. The rectus muscles are freed at their inner margins and retracted outward with the skin, fat, and anterior sheaths to expose the posterior rectus sheaths. A transverse incision is made across the midline and through the posterior sheaths, peritoneum and falciform ligament. The falciform ligament contains blood vessels which require ligation.

Singleton has modified the Sloan incision by making a transverse skin incision, a longitudinal incision in the right rectus fascia, and a transverse incision in the left fascia. The rectus muscles are retracted laterally on each side. Through a transverse skin incision, Sanders divides the anterior sheaths of both recti transversely and retracts both muscles as in the Sloan incision (Fig. 351).

The posterior sheaths of the rectus muscles are closed with the peritoneum. The margins are everted to minimize adhesions. Tension on the wound margins is not great, and no difficulty is experienced in closure. The sheath fibers extend trans-

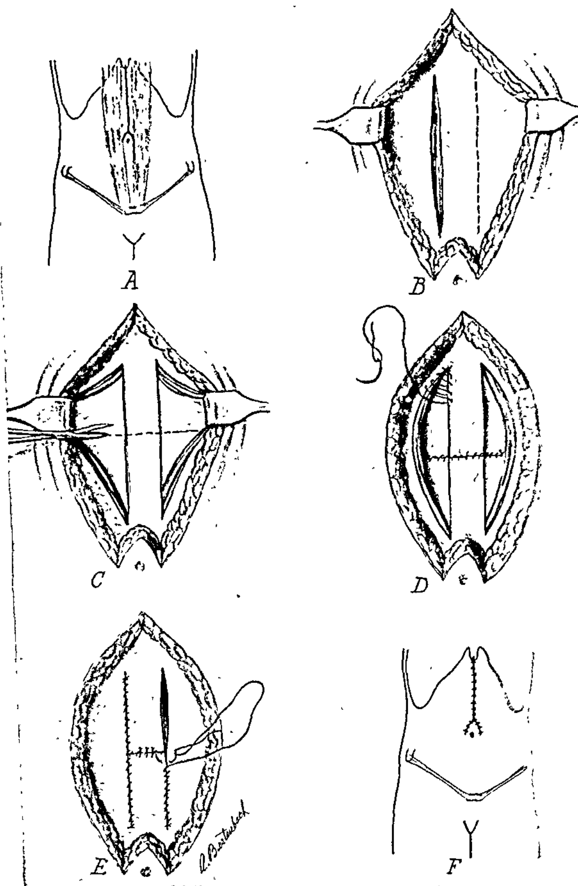


FIGURE 350 Sloan upper abdominal incision. *A*, Line of skin incision. *B*, Lines of incision through the anterior sheaths of both rectus muscles. *C*, Rectus muscles freed along their inner margins and retracted laterally. Dotted line shows line of transverse incision across the middle, posterior sheath of the rectus muscles and peritoneum *D*, Method of closure of the posterior rectus sheath and peritoneum *E*, The rectus muscles replaced and anterior sheaths of the rectus muscles being closed. *F*, Line of sutures in the skin (Redrawn from Sloan· Surg , Gynec. & Obst.)

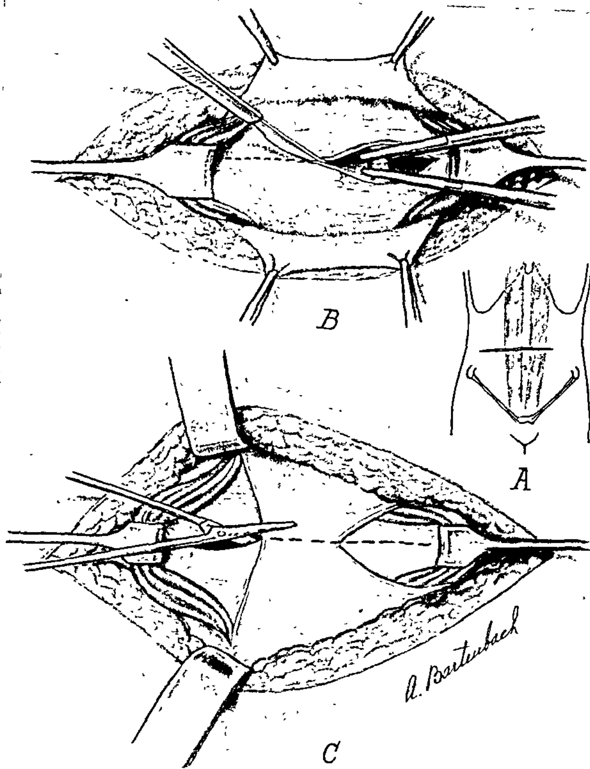


FIGURE 351 Sanders incision *A*, Line of skin incision *B*, Anterior sheaths of rectus muscles opened with muscles retracted laterally The round ligament of the liver is clamped preparatory to section and ligation, and the posterior rectus sheaths are being cut transversely (Redrawn from Sanders Ann. Surg., July, 1936) *C*, Singleton's modification of the Sloan incision (Redrawn from Singleton and Blocker J A M A)

versely, affording good holding power for sutures. Chromic catgut continuous sutures may be used in the fascia. If silk is used, all buried sutures should be interrupted.

The rectus muscles are replaced and held in position with a few interrupted sutures. The anterior sheaths are readily closed without tension. The skin is closed with silk.

If a drain is necessary, it should emerge at one end of the posterior sheath incision through a stab wound at the outer margin of the rectus muscle.

THE PFANNENSTIEL INCISION

This lower abdominal transverse incision is preferred by some surgeons for pelvic work. It is doubtful whether it is superior to a well made paramedian incision.

Technique (Fig. 352)

A transverse incision with a slight curve downward is made with its midportion at the midline. It is placed about 4 cm. above the pubes and is made about 10 cm. long. The sheaths of the rectus muscles are divided in the direction of the skin incision, but the musles are not cut. An upper flap of skin, fat and fascia is dissected from the

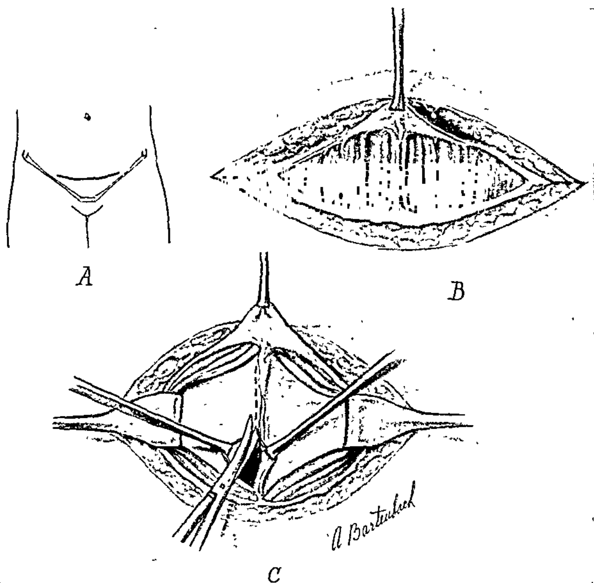


FIGURE 352. Pfannenstiel transverse lower abdominal incision. *A*, Line of skin incision. *B*, The sheaths of the rectus muscles are separated upward from the surfaces of the muscles. *C*, The rectus muscles are separated from the midline and retracted laterally. The peritoneum is divided near the midline

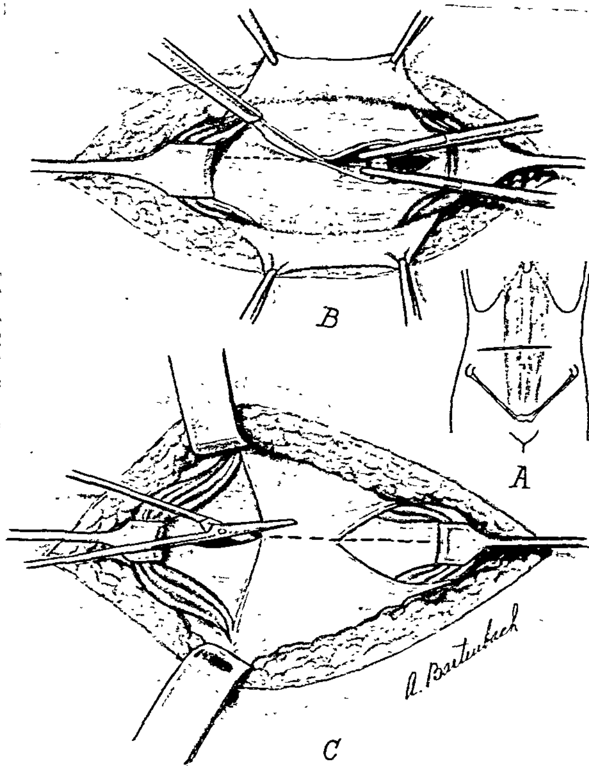


FIGURE 351. Sanders incision. *A*, Line of skin incision. *B*, Anterior sheaths of rectus muscles opened with muscles retracted laterally. The round ligament of the liver is clamped preparatory to section and ligation, and the posterior rectus sheaths are being cut transversely. (Redrawn from Sanders Ann Surg, July, 1936) *C*, Singleton's modification of the Sloan incision. (Redrawn from Singleton and Blocker: J A M A)

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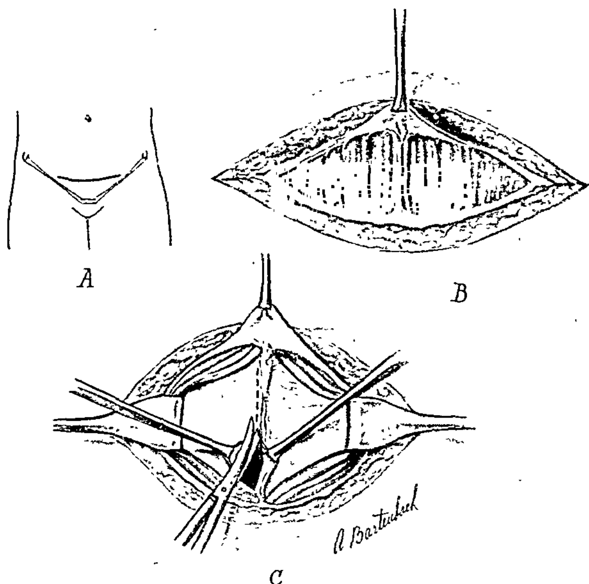


FIGURE 352. Pfannenstiel transverse lower abdominal incision. *A*, Line of skin incision. *B*, The sheaths of the rectus muscles are separated upward from the surfaces of the *muscles C*, The rectus muscles are separated from the midline and retracted laterally. The peritoneum is divided near the midline.

muscles a distance of about 8 cm. The muscles are separated, and the peritoneum is opened in the midline.

The wound is closed in layers, using silk or catgut. This makes a strong closure, but because of the trauma necessary for making the incision, hematomas may occur and infections are more serious than in other types of incisions.

THE CHERNEY INCISION

Technique (Fig. 353)

A curvilinear incision is made above the pubes within the upper pubic hairline, connecting points about 5 cm. medial to each of the anterior superior spines. The aponeuroses of the external oblique muscles and the anterior sheaths of the rectus muscles are incised. The fibers of the internal oblique muscles are split. The lower flap of the rectus sheaths is separated from the rectus and pyramidalis muscles by blunt and sharp dissection down to the pubic bones.

Through their fibrous insertions to the pubes the rectus muscles are severed transversely. The detached muscles are reflected upward above the line of the abdominal incision. The peritoneum is opened above the bladder reflection and extended laterally in both directions by dividing the transversalis muscles with the peritoneum. It may be necessary to divide and ligate the inferior epigastric vessels.

The peritoneum may be closed with interrupted sutures of silk or cotton. Lateral to the rectus margins the transversalis may be included in the peritoneal sutures. Good abdominal relaxation is necessary to unite the fibrous ends of the rectus muscles to the pubes. Mattress sutures are preferred. The aponeuroses of the external oblique muscles, the internal oblique muscles and the sheaths of the rectus muscles are closed with interrupted sutures. The superficial fascia and skin are closed separately. An indwelling catheter must be used within the bladder to prevent accidental injury when using such low abdominal incisions.

THE SINGLETON LATERAL OBLIQUE INCISION

This incision is used on the right side for operations upon the biliary tract and on the left for operations on the splenic flexure of the colon and spleen. It permits closure of the rectus sheath in a direction opposite to the direction of its fibers and suture of the external oblique, internal oblique, and transversalis muscle and peritoneum with a minimum of tension. Disruption of this wound is rare.

Technique of Singleton Incision (Fig. 354)

An incision 12 to 15 cm. in length is made, beginning at the midline about midway between the ensiform process and umbilicus and extending outward and downward toward the iliac crest just posterior to the anterior iliac spine. The anterior sheath of the rectus is cut transversely, and the muscle is freed from the sheath a short distance above and below. The external oblique is divided in line with the cutaneous incision. The rectus muscle is retracted toward the midline, and its posterior sheath is incised. This incision is extended laterally to divide the internal oblique muscle in the direction of its fibers and to cut the transversalis and peritoneum. The tenth inter-

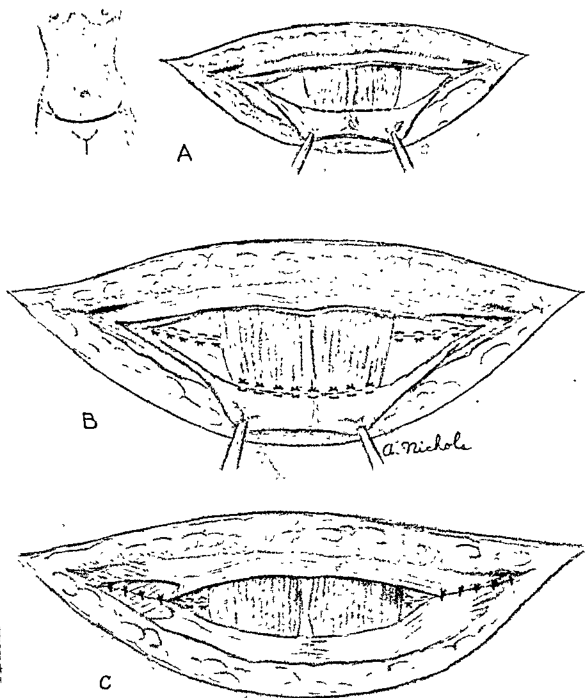


FIGURE 353 Technique of a low transverse abdominal incision. Inset shows line of incision. *A*, Flap of rectus sheath has been reflected downward Line of incision near insertion of recti muscles to pubes *B*, The peritoneum and transversalis fascia closed with mattress sutures of silk. Recti muscles sutured to their tendon attachments and to lower flap of rectus sheath. *C*, Method of closure of internal and external oblique muscles (Redrawn from Cherney: Surg , Gynec. & Obst., Vol. 72.)

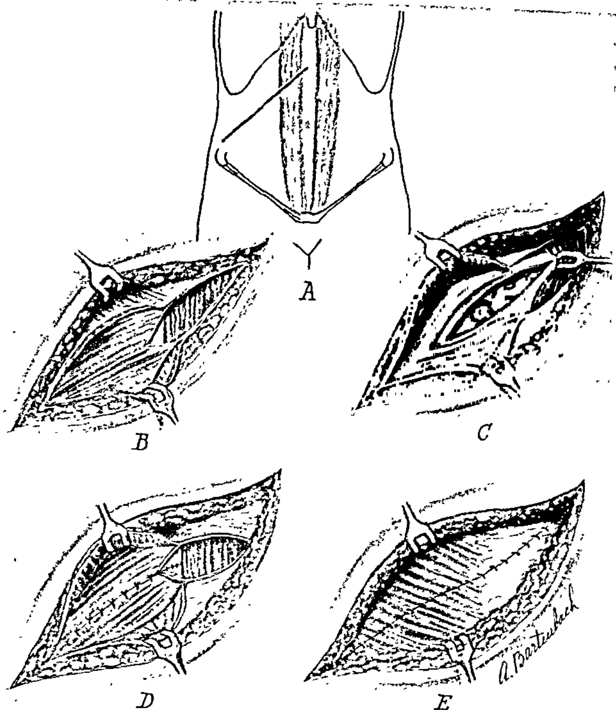


FIGURE 354 Steps in the Singleton lateral oblique incision. *A*, Skin incision *B*, Anterior sheath of the rectus muscle and external oblique divided *C*, Rectus muscle retracted medially, the posterior sheath of the rectus divided and the internal oblique muscle, transversalis muscle and peritoneum divided in the line of the fibers of the internal oblique muscle. *D*, Posterior sheath of the rectus muscle, internal oblique muscle, transversalis muscle and peritoneum closed in one layer. *E*, Anterior sheath of the rectus muscle and external oblique muscle closed as one layer. (Redrawn from Singleton and Blocker: J.A.M.A)

costal nerve is retracted with the rectus muscle, the eleventh is cut, and the twelfth is retracted laterally. Numbness due to section or trauma of the nerves may be felt for a few weeks below the incision.

The incision is closed in layers, with either interrupted sutures of silk or continuous catgut sutures. The retracted rectus muscle is replaced, and the anatomical structures are accurately approximated.

LOWER ABDOMINAL OBLIQUE INCISION

The lower abdominal oblique incision is suitable for operations upon the cecum, ascending colon, terminal ileum, sigmoid and descending colon.

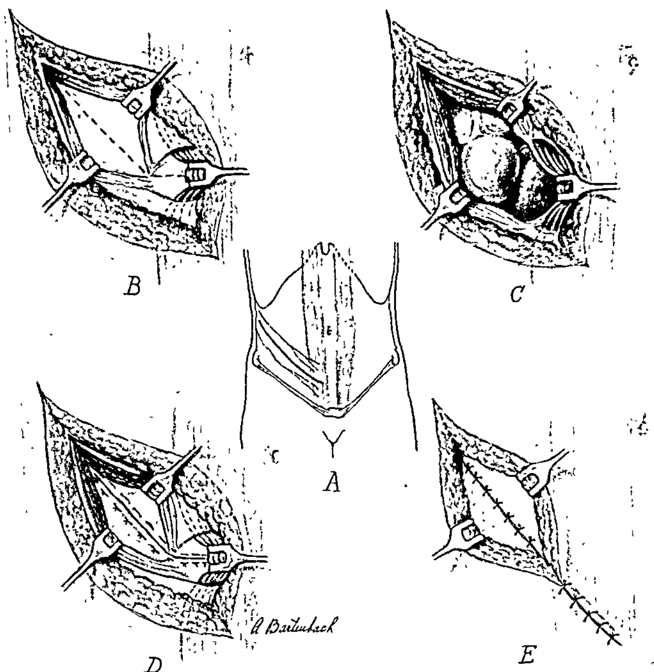


FIGURE 355 Oblique lower abdominal incision. *A*, Line of incision in skin and fascia This incision is made parallel to and between the nerves. *B*, External oblique is divided parallel with its fibers. The internal oblique and transversalis muscles are cut across. Peritoneum is incised parallel with the skin. Anterior and posterior sheaths of the rectus muscle are incised, and the rectus muscle is retracted medially. *C*, Wound opened, exposing cecum and terminal ileum. *D*, Closure of posterior rectus sheath and peritoneum with interrupted mattress sutures This closure may include in one layer the peritoneum and the transversalis and internal oblique muscles. *E*, Closure of anterior sheath of the rectus muscle and external oblique aponeurosis and muscle with interrupted sutures. Skin may be closed with interrupted or continuous sutures. If silk is used, all buried sutures should be interrupted.

Technique (Fig. 355)

The skin incision begins in the flank and extends downward and inward about 5 cm. medial to the anterior superior spine, crosses the lateral margin of the rectus muscle, and ends near the midline. The external oblique muscle with its aponeurosis is split parallel with its fibers to the edge of the rectus muscle. The incision is extended medially to divide the anterior sheath of the rectus muscle. The sheath is separated from the muscle upward and downward to permit retraction of the muscle medially. By following the line of incision through the external oblique, the internal oblique and transversalis muscles are cut across their fibers to the rectus margin. The peritoneum and posterior sheath of the rectus are divided the full length of the incision. This incision lies between the eleventh and twelfth dorsal nerves. Closure of the incision is made in layers. The posterior sheath of the rectus is closed first. It is usually most convenient and satisfactory to close the peritoneum, transversalis and internal oblique muscles in one layer. If the internal oblique muscle is well developed, it may be closed in a separate layer. After replacing the margin of the rectus muscle, its anterior sheath and the external oblique are closed. Continuous sutures of catgut or interrupted silk or cotton sutures may be used. The skin is sutured with silk. When a drain is necessary, it should emerge at the lateral end of the incision.

McBURNEY INCISION

The cecum and appendix can usually be exposed through the McBurney incision. It is used chiefly for cecostomy and appendectomy. If there is any doubt about the diagnosis, a paramedian or Battle incision permits more thorough abdominal exploration than the McBurney incision.

Technique (Fig. 356)

The skin incision is usually made about 8 cm. in length. It begins above a line between the anterior superior iliac spine and the umbilicus about 4 cm. medial to the anterior superior spine. It extends downward and inward parallel to the fibers of the external oblique muscle and fascia.

The external and internal oblique and transversalis muscles are separated parallel to their fibers and retracted to expose the peritoneum. The peritoneum is incised in any direction desired. The ilioinguinal nerve passes medial to the anterior superior spine and lies between the internal oblique and transversalis muscles Injury to this nerve may result in paralysis of the falx inguinalis (conjoined tendon), to which it gives off a motor branch, predisposing to inguinal hernia.

If the McBurney incision proves inadequate, it may be enlarged medially by extending the skin incision and cutting across the anterior and posterior sheaths of the rectus and retracting the rectus medially (Weir's modification) (Fig. 356). The sheaths of the rectus should be separated from the muscle a short distance upward and downward to facilitate retraction of the muscle toward the midline.

The McBurney incision is closed in layers. A continuous mattress or purse-string suture may be used in the peritoneum to evert the wound margins. Two or three interrupted sutures will close the internal oblique, and continuous or interrupted

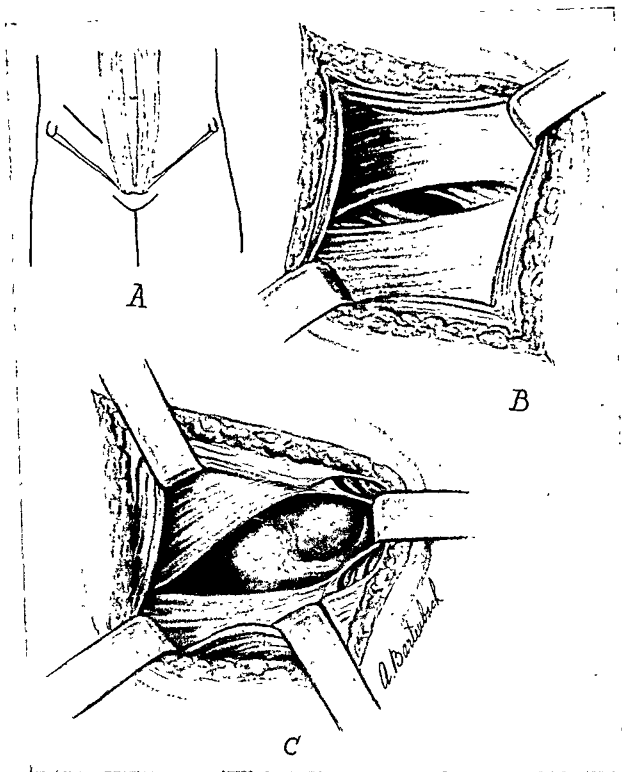


FIGURE 356. McBurney incision. *A*, Line of skin and fascia incision. *B*, The fibers of the external oblique have been split and retracted Internal oblique and transversalis muscles split parallel with their fibers *C*, Weir modification of the McBurney incision. To enlarge the McBurney incision, the anterior and posterior sheaths of the rectus muscle are divided, and the rectus muscle is retracted medially.

sutures are used in the external oblique and skin. When the Weir extension is necessary, the rectus sheaths are closed with interrupted sutures.

ABDOMINOTHORACIC INCISION (HOOD AND KIRKLIN)

General Considerations

The indications for the use of an abdominothoracic incision such as described by Hood and Kirklin are carcinoma of the lower esophagus and esophagogastric region, certain hiatus hernias, a gastric lesion requiring total gastrectomy and possibly splenorenal anastomosis in portal hypertension.

Technique

The patient may be positioned on the table in either position (Fig. 357, 358) according to the nature of the lesion for which the operation is to be performed. The skin incision extends from just to the right of the midline obliquely to the left across the eighth costal cartilage and over the seventh interspace. Ordinarily the abdominal portion of the incision is completed first to allow exploration of the abdominal viscera. In the event an operable lesion is found, the thoracic portion of the incision is completed by incision of the external oblique muscles, the latissimus dorsi and serratus anterior muscles, exposing the costal cartilages and muscles of the seventh intercostal space. Entry of the chest is then accomplished in approximately the midaxillary line and carried down toward the costal arch. When the costal arch is transected, it is done in a V-shaped manner so that its reconstruction is strengthened in closing. The diaphragm may then be divided down to the hiatus or to whatever length is indicated by the operative procedure. Exposure is greatly facilitated by the use of a rib-spreading retractor.

On completion of the operative procedure the diaphragm is reconstructed with interrupted sutures of nonabsorbable material. The most lateral portion of the dia-

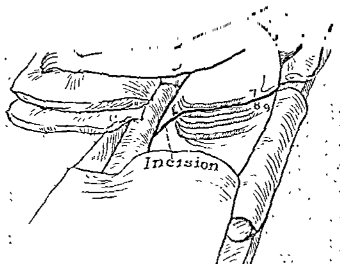
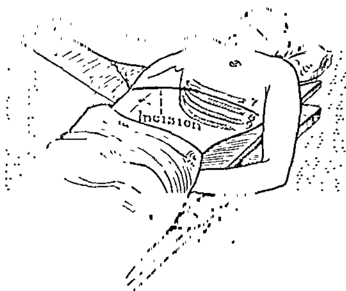


FIGURE 357. Position of the patient on the operating table for operations on the lower portion of the esophagus, the esophagogastric junction and the gastric cardia. (R. T. Hood and J. W. Kirklin: S Clin. North America, Vol. 33.)

FIGURE 358. Position of patient on the operating table for operations of hiatal hernia, total gastrectomy or splenorenal anastomosis. (R. T. Hood, Jr., and J. W. Kirklin: S. Clin. North America, Vol. 33.)



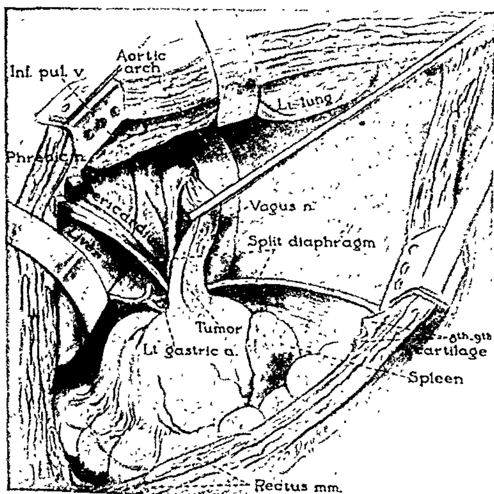


FIGURE 359. Illustrating the extent of the exposure obtained by the use of the abdominothoracic incision. (R. T. Hood, Jr., and J. W. Kirklin: S. Clin. North America, Vol. 33.)

phragm cannot be closed until after the reconstruction of the costal arch. Sutures through this area of the diaphragm may be placed and tied from the abdominal side after closure of the chest. Hood and Kirklin recommend that in the placement of encircling or paracostal sutures immediately above and below the incision, usually three in number, heavy-gauge silk be used for this procedure. No attempt is made to obtain airtight closure of the intercostal muscles. The external oblique, latissimus dorsi and serratus anterior muscles are then reapproximated in layers. Before closure of the thorax, an intercostal tube is inserted for temporary suction drainage to maintain lung expansion. The remaining abdominal portion of the wound may then be closed by any appropriate technique.

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CHAPTER 13

Digestive System

Operations upon the Esophagus

General Considerations

The esophagus is a muscular collapsible tube extending from the pharynx to the stomach, a distance of about 25 cm. in the adult. Its upper end is opposite the sixth cervical vertebra and its lower end on a level with the tenth or eleventh dorsal vertebra. The normal constrictions are located at the level of the aortic arch, the left bronchus and cardiac end. Surgical lesions are more likely to develop at these narrowings. Because of inaccessibility and operative hazards, surgery of the esophagus has been slow in development. The introduction of the esophagoscope has made possible many safe operations within the esophagus which were formerly dangerous by other methods. Few foreign bodies now require removal through surgical incisions. More accurate diagnosis of lesions within the esophagus by means of the esophagoscope has simplified and rationalized necessary surgical procedures.

Perforation of the esophagus is usually an indication for prompt operation. The various approaches for such wounds are described in the section on the operative treatment of mediastinitis.

From the standpoint of surgical approach, the esophagus may be divided

into cervical, thoracic and abdominal portions. The methods of surgical approach are cervical, transpleural, extrapleural and abdominal, or their combinations.

REPAIR OF ESOPHAGEAL WOUNDS AND REMOVAL OF FOREIGN BODIES

Technique of Cervical Esophagotomy

A method of exposure of the cervical portion of the esophagus is described in the technique for operation upon esophageal diverticulum. Injury to the recurrent laryngeal nerve should be carefully avoided. A foreign body is removed through a longitudinal incision in the esophagus. The wound is then closed with two rows of interrupted fine silk sutures. The inner row approximates the mucosa, and the sutures are placed by passing the needle through one edge from within the lumen and back through the opposite edge from without into the lumen, so that the resulting knot lies *within the lumen. The second layer consists of mattress sutures to approximate the* muscle layers. Leakage from such wounds may occur, since primary union of the esophageal wall is less likely than of the intestinal wall, which is covered with peritoneum. Severe or fatal mediastinitis may result from leakage. Adequate drainage down to the esophagus is always advisable.

Accidental wounds of the cervical esophagus should be closed with sutures when possible. Here the danger of mediastinitis is great and efficient drainage imperative. Feedings through an indwelling nasal tube for a week following operation are advisable after most wounds of the esophagus.

OPERATION FOR ESOPHAGEAL DIVERTICULUM

General Considerations

Diverticula of the esophagus are of two types, *traction* and *pulsion.* The former usually occurs within the thorax as a result of cicatricial contraction. Pulsion di-

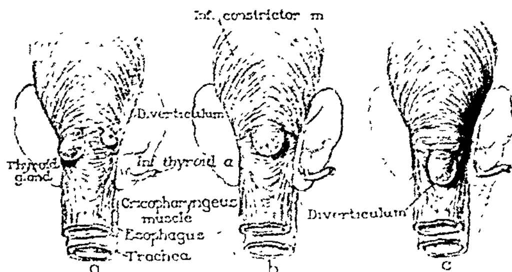


FIGURE 360 Four sites of origin of pharyngoesophageal diverticula *a,* Diverticula protruding through the right and left posterolateral walls between the inferior constrictor and cricopharyngeus muscles. *b,* Diverticulum in the midline between the inferior constrictor and cricopharyngeus muscles. *c,* Diverticulum in the midline protruding through or immediately beneath the cricopharyngeus muscle. (Harrington: Surgery, Vol. 18, C V Mosby Company)

verticula occur at the pharyngoesophageal junction between the inferior constrictor and cricopharyngeus muscle, or through the cricopharyngeus muscle (Fig. 360). The pouch of the diverticulum extends downward into the prevertebral space behind the esophagus, usually somewhat to the left of the midline. Large diverticula may extend into the upper mediastinum. Operative treatment is indicated when a diverticulum produces symptoms. The location and size of the pouch should be determined by x-ray study.

Dangers and Safeguards

The greatest danger of operation is *infection*, which may extend into the fascial planes of the neck and downward into the mediastinum. Such a complication has a high mortality rate. Since the sac lies between the esophagus and vertebrae, often extending into the upper mediastinum, any leakage during operation might cause fatal *mediastinitis*. Great care must, therefore, be used not to wound the sac or esophagus during operation. The *recurrent laryngeal nerve* lies in the groove between the esophagus and trachea and may be injured during dissection. The point of greatest danger is that at which the nerve enters the larynx. The *vocal cords* should be examined both before and after operation. Other complications which may follow operation are *fistula* or *constriction of the esophagus*. Incomplete removal of the diverticulum may require a second operation. Carcinoma may rarely be found in an esophageal diverticulum.

Lahey recorded a series of 209 cases operated upon by the two-stage method with two deaths. In a series of 115 cases operated upon by the one-stage method Harrington had no deaths. It is obvious that either the one-stage or the two-stage operation is satisfactory when done by a skilled surgeon. With the ready availability of antibiotics the hazards of infection are less, and the one-stage procedure has replaced the two-stage operation in most areas. It is probable that the two-stage operation is safer for the surgeon who has had a limited experience with the operation.

Technique of One-Stage Diverticulectomy (Figs. 361, 362)

The operation is done under general endotracheal anesthesia, the patient lying on his back and the head extended in a position similar to that used for thyroidectomy. Hyperextension of the head and neck is to be avoided, since this may limit the space between the trachea and the vertebral bodies and make mobilization of the diverticulum more difficult. Passage of a Levin tube into the esophagus before operation may facilitate identification of the esophagus; it may be difficult or impossible, however, to pass such a tube without doing so under direct vision through the esophagoscope, and most authors do not recommend use of the Levin tube. Since most of these lesions present on the left side, a left-sided incision is usually made; in rare instances, however, the diverticulum may be approached from the right.

An oblique incision is made over the inner border of the sternocleidomastoid muscle from the level of the hyoid bone to a point 2 cm. above the clavicle. A transverse incision is satisfactory also. If the external jugular vein crosses the line of incision, it is cut and ligated. Incision through the platysma muscle exposes the sternocleidomastoid muscle. The latter muscle is separated from the omohyoid and sternohyoid muscles by blunt dissection, although it may be necessary to cut the omohyoid.

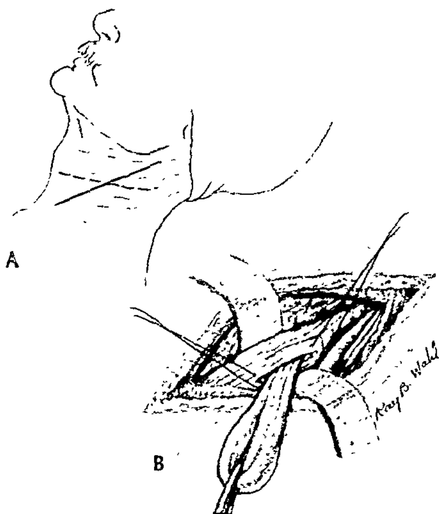


FIGURE 361. Technique of one-stage diverticulectomy. *A*, Either an oblique or a transverse skin incision may be used. *B*, The sac has been dissected away from surrounding tissues and stay sutures placed in the muscularis above and below to delineate the ends of the defect.

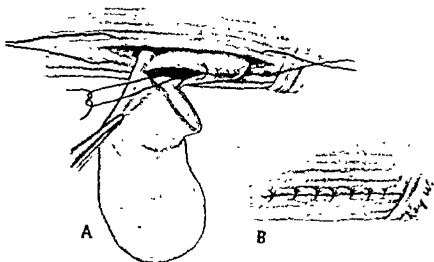


FIGURE 362 Technique of one-stage diverticulectomy (*concluded*) *A*, Detail of method of amputation and closure of the neck of the sac, using fine interrupted silk sutures placed in such fashion that the knots lie inside the esophageal lumen. *B*, Closure of the muscularis with interrupted silk sutures. A few additional mattress sutures may be added for reinforcement.

By retracting the sternocleidomastoid muscle laterally and the sternohyoid medially, the carotid sheath and thyroid gland are exposed.

It is usually necessary to divide the middle thyroid vein and the inferior thyroid artery to obtain adequate exposure. With the thyroid retracted medially and the carotid sheath and sternocleidomastoid muscle retracted laterally, the esophagus and diverticulum can be identified. By entering the retropharyngeal space and enlarging this area by sharp and blunt dissection, the diverticulum can be found, carefully freed from the surrounding attachments and mobilized out through the incision. The neck of the sac is then carefully developed. The danger of perforation is greatest as the neck of the sac is dissected down to its opening in the muscular wall of the pharynx. It is at this point also in the dissection that the recurrent laryngeal nerve may be injured. A few small vessels are encountered extending from the wall of the pharynx over the surface of the diverticulum. These should be cut and ligated. Fibers of the inferior constrictor and the cricopharyngeus muscle are separated and removed from the sac. The muscular wall may be thin around a large opening and must be dissected carefully to reduce the size of the neck as much as possible. After developing the sac and neck in this fashion, stay sutures of fine silk are placed in the muscularis to delineate the upper and lower ends of the defect in the muscularis. The neck of the sac is then amputated, taking care to leave an adequate stump to avoid retraction of the walls with resultant concentric narrowing of the pharynx following closure.

After cutting the mucosal layer of the neck of the sac partway across at its upper end, the first mucosal sutures are inserted. This is done by passing the needle through one edge from within the lumen and back through the opposite edge in the reverse direction so that after the knot has been tied it lies on the inside. The mucosal portion of the neck of the sac is then further divided and the sutures placed in the same fashion until the neck has been completely divided and the defect closed. Fine interrupted silk sutures are used throughout. The edges of the muscularis are next approximated over the mucosal suture line, using fine interrupted silk sutures. A few mattress sutures to invert the suture line may be used. The esophagus is then allowed to fall back in its normal position, and the suture line should be posterior. The wound is irrigated carefully and closed with interrupted silk. If a drain is to be used, care must be taken that it does not impinge upon the suture line.

Antibiotics are used postoperatively, and care should be taken to avoid retching and vomiting. The patient is placed on nothing by mouth for the first forty-eight hours and given intravenous feedings. Liquids are then given in limited amounts and feeding gradually increased.

Technique of Two-Stage Diverticulectomy (Lahey) (Figs. 363, 364, 365)

Local anesthesia may be used in selected cases. Lahey prefers general anesthesia given with an intratracheal tube. The operation is usually done through the left side of the neck. Rarely a diverticulum extends to the right, and then a right-sided approach is advisable for good exposure of the neck of the sac.

First Stage. An incision is made over the anterior border of the sternocleidomastoid muscle from above the level of the upper pole of the thyroid downward to the point of insertion of the sternocleidomastoid at the sternum. A long incision is neces-

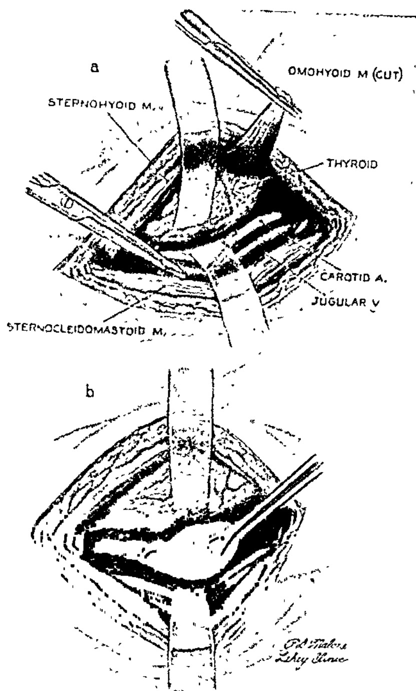


FIGURE 363. Technique of two-stage esophageal diverticulectomy. *a*, Wound open with retractors in place to retract the thyroid medially and the carotid sheath laterally. The omohyoid has been divided through its tendon, and the anterior belly is to be removed. *b*, The diverticulum has been exposed, dissected from its attachment to the longitudinal esophagus and drawn upward (Lahey: Ann Surg, Vol 124, J. B Lippincott Company)

sary for good exposure. The platysma is cut, and the sternocleidomastoid muscle is separated throughout the length of the incision from the underlying prethyroid muscles. By retracting the sternocleidomastoid muscle laterally, the omohyoid muscle is exposed. This latter muscle is followed to its point of insertion, clamped and ligated, and the anterior belly is removed. The sternohyoid muscle is retracted medially, and the sternocleidomastoid muscle and carotid sheath are retracted laterally to expose the thyroid gland and its vessels. The lateral thyroid veins and the inferior thyroid artery and vein are doubly ligated and divided. This division of ves-

sels permits retraction of the thyroid gland medially and the jugular vein and carotid artery laterally to expose the esophagus and diverticulum.

The diverticulum is identified and grasped with Babcock forceps. The sac is gently lifted as it is freed by blunt dissection. Finger dissection may be useful in elevating a large sac which extends into the upper mediastinum. Dissection must be complete up to the neck and around the neck until the pale white membrane of the submucosa is shown. The dissection about the neck must be done carefully to avoid puncture of the sac. If difficulty is experienced in freeing the right side of the neck of

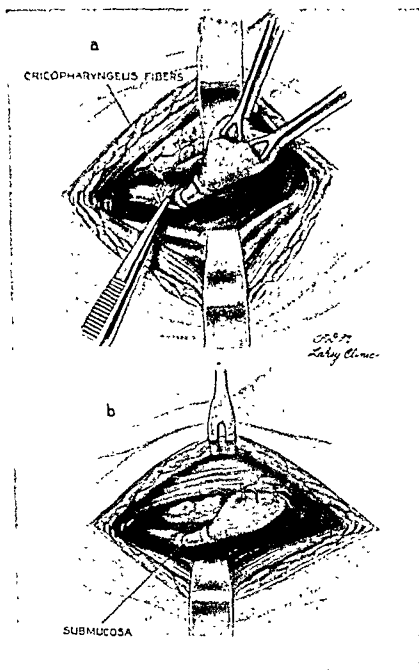


FIGURE 364 Technique of two-stage esophageal diverticulectomy (*continued*). *a*, The dissection of the neck of the sac has been completed, exposing the pale white surface of the submucosa. The fibers of the cricopharyngeus muscle have been separated from the neck of the sac. *b*, The sac has been sutured to the margin of the sternohyoid muscle. The sutures pass through the adventitia about the sac, but not through its wall. The black silk sutures aid in identification of the sac at the second stage. (Lahey: Ann. Surg, Vol. 124, J. B. Lippincott Company.)

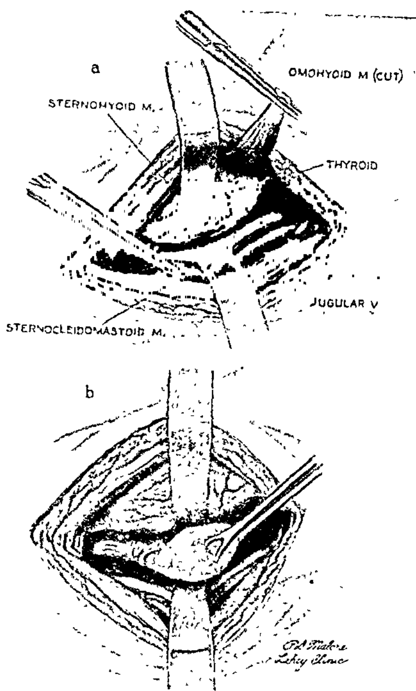


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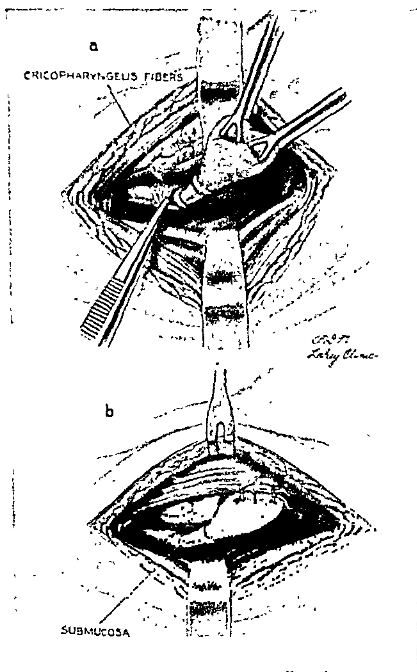


FIGURE 364 Technique of two-stage esophageal diverticulectomy (*continued*) *a*, The dissection of the neck of the sac has been completed, exposing the pale white surface of the submucosa. The fibers of the cricopharyngeus muscle have been separated from the neck of the sac. *b*, The sac has been sutured to the margin of the sternohyoid muscle. The sutures pass through the adventitia about the sac, but not through its wall. The black silk sutures aid in identification of the sac at the second stage. (Lahey· Ann Surg., Vol. 124, J. B Lippincott Company.)

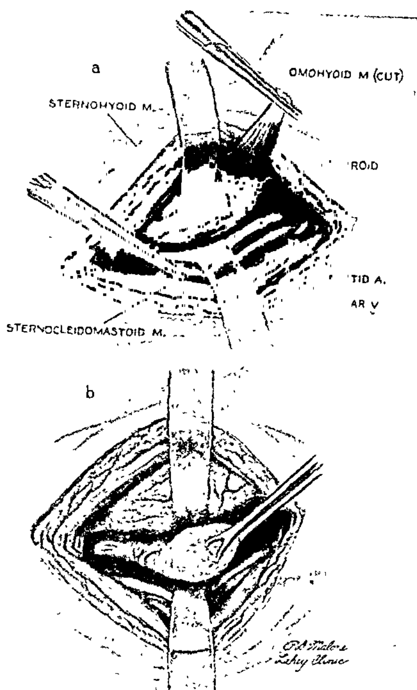


FIGURE 363. Technique of two-stage esophageal diverticulectomy. *a*, Wound open with retractors in place to retract the thyroid medially and the carotid sheath laterally. The omohyoid has been divided through its tendon, and the anterior belly is to be removed *b*, The diverticulum has been exposed, dissected from its attachment to the longitudinal esophagus and drawn upward. (Lahey: Ann. Surg, Vol. 124, J B Lippincott Company)

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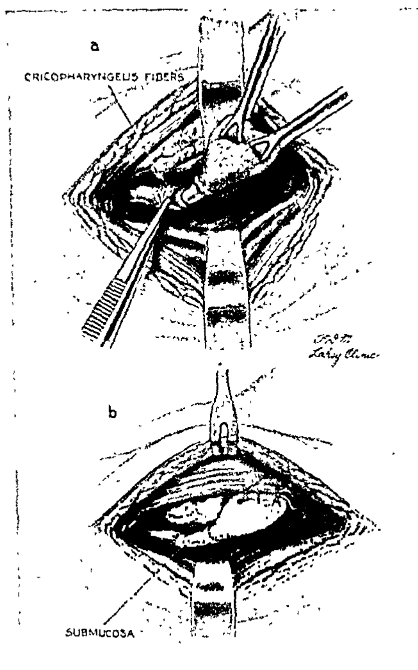


FIGURE 364. Technique of two-stage esophageal diverticulectomy (*continued*). *a*, The dissection of the neck of the sac has been completed, exposing the pale white surface of the submucosa. The fibers of the cricopharyngeus muscle have been separated from the neck of the sac. *b*, The sac has been sutured to the margin of the sternohyoid muscle. The sutures pass through the adventitia about the sac, but not through its wall. The black silk sutures aid in identification of the sac at the second stage. (Lahey: Ann. Surg, Vol 124, J. B Lippincott Company.)

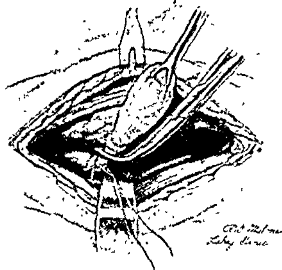


FIGURE 365 Technique of two-stage esophageal diverticulectomy (*concluded*) Method of double ligation of the neck of the sac at the second stage of the operation. The first ligature is tied, and the second ligature is placed ready for tying. A clamp has been placed on the neck distal to the second ligature The neck is to be severed between the clamp and distal ligature. (Lahey: Ann. Surg, Vol 124, J B Lippincott Company)

its muscular covering, this part of the dissection may be delayed until the second stage of the operation, when the fascial planes and mediastinum are sealed and protected from infection.

After the sac and its neck have been completely freed the sac is lifted upward to convert the acute angle between the neck and the esophagus into an obtuse angle. The sac is then sutured to the outer margin of the sternohyoid muscle with stitches of black silk which do not penetrate its wall. The esophagus must lie in the midline and not be rotated or angulated by traction on the sac. If a large cavity exists after displacing the diverticulum, it is packed with gauze. The pack is removed on the fourth postoperative day. The wound is closed between the muscles and in the skin with sutures of fine silk.

Second Stage. This stage of the operation may be done at any time from the seventh to the twelfth day after the first stage. The second stage must not be postponed until cleavage planes are obliterated by healing.

The wound is opened through the scar, and the tissues are separated and retracted as in the first stage. The black silk sutures aid in the identification of the sac. The stitches are cut, and the sac is gently freed down to its neck. The neck is doubly ligated with no. 0 chromic catgut flush with the wall of the esophagus. To prevent soiling, the neck is clamped and severed distal to the ligatures. If the opening into the esophagus is large, it should be sutured. The mass of tissue about a large opening is not suitable for ligation. A cigarette type of drain is passed into the wound, but not in contact with the ligated neck. The wound is closed with silk.

A Levin tube is passed through the nose into the stomach before or during the operation, and through it the patient should be fed for seven days.

CONGENITAL ESOPHAGEAL ATRESIA AND TRACHEO-ESOPHAGEAL FISTULA

General Considerations

Congenital atresia of the esophagus may exist with or *without tracheo-esophageal* fistula. Early operation is necessary to prevent death from pneumonia or starvation. Although the operative mortality rate is high, surgical therapy is indicated in all cases unless other anomalies are present which are incompatible with life.

Gastrostomy as a definitive treatment is not satisfactory. It may be used as a step in other operations so that patients may be fed temporarily. Longmire recommends that a Stamm type of gastrostomy be made forty-eight hours after the anastomosis

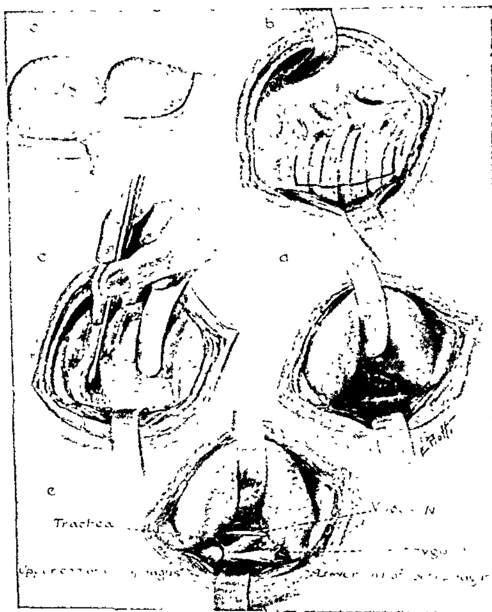


FIGURE 366. Technique of end-to-end esophageal anastomosis for congenital atresia. Operative approach after Lanman, Ladd and Haight and Towsley. *a*, Curvilinear incision medial to right scapula. *b*, Scapula retracted and portions of third, fourth and fifth ribs resected subperiosteally. Intercostal muscles, nerves and vessels to be cut along the black line. *c*, The parietal pleura is peeled off of the ribs and vertebrae and retracted anteriorly. A transpleural intercostal approach is now preferred by most surgeons *d*, Azygos vein exposed. *e*, Azygos vein divided and ligated. Both ends of esophagus and site of tracheo-esophageal fistula exposed (Gross and Scott: Surg., Gynec. & Obst., Vol. 82. By permission of Surgery, Gynecology and Obstetrics.)

operation. The gastrostomy not only provides a way for feeding the patient, but also permits retrograde dilatation of the esophagus through the gastrostomy stoma if a stricture develops.

Two types of operation have been used successfully. The first type, and the operation of choice, is a direct end-to-end anastomosis. If the ends of the esophagus are too far apart (more than 2 cm.), it may be necessary to elevate the stomach into the chest and anastomose the proximal end of the esophagus to the fundus of the stomach.

A complication of tracheo-esophageal anastomosis is postoperative fistula, which usually closes spontaneously. Strictures may complicate the operation and require dilations for several weeks. Dilations should be continued until a no. 20 French dilator can be passed with ease.

Technique of End-to-End Anastomosis (Gross and Scott)

Exposure can best be obtained through a right posterolateral thoracotomy incision entering the pleural cavity through the fourth or fifth interspace. The extrapleural approach provides less exposure and is unnecessary with antibiotic coverage. The azygos vein is doubly ligated and divided (Fig. 366). By further dissection into the mediastinum the esophagus is exposed and carefully separated from all areolar tissue. The segments of the esophagus are mobilized. If a tracheo-

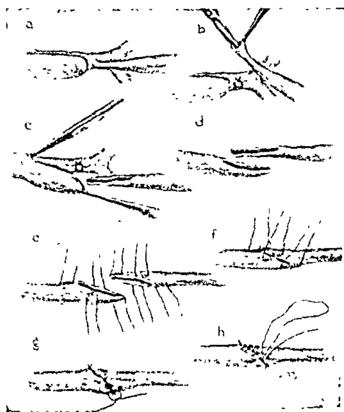


FIGURE 367 Technique of end-to-end esophageal anastomosis for congenital atresia (*concluded*) *a*, Blind upper esophageal pouch shown at left. Lower esophageal segment communicates with lower part of trachea *b*, The tracheo-esophageal fistula has been ligated and divided. Lower segment mobilized down to diaphragm *c*, Upper segment separated from trachea Lower segment split ready for anastomosis *d*, Upper segment opened *along its anterior surface* *e*, Four stay sutures placed in each segment *f*, Proximal ends of stay sutures tied. *g*, Distal ends of stay sutures tied to roll in ends of esophagus *h*, Anastomosis completed with interrupted sutures of fine silk. (Gross: Surg, Gynec. & Obst, Vol 82 *By permission of Surgery, Gynecology and Obstetrics*)

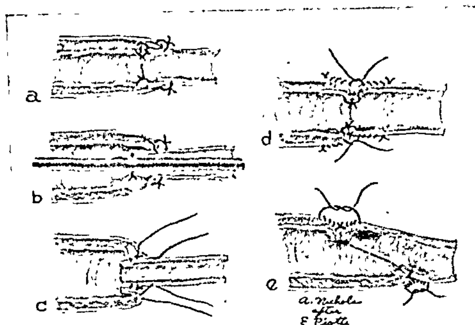


FIGURE 368. Schematic drawings of various techniques of end-to-end anastomosis for esophageal atresia. *a*, Haight. *b*, Daniel. *c*, Humphreys. *d*, Ladd. *e*, Gross and Scott. (Redrawn from Gross and Scott· Surg., Gynec & Obst, Vol. 82.)

esophageal fistula exists, it is ligated near the trachea. A slit is cut in each segment of the esophagus, and an end-to-end anastomosis is made, using no. 5-0 silk (Fig. 367). A no. 8 urethral catheter is passed through the nose and the two segments of the esophagus into the stomach over which the anastomosis is made. A drain is placed down to the mediastinum, and the wound is closed with silk.

Other types of end-to-end esophageal anastomosis are shown in Figure 368.

OPERATIONS FOR ACHALASIA OR CARDIOSPASM

General Considerations

This condition is characterized by evidence of obstruction at the cardiac end of the esophagus with a concurrent dilatation of the esophagus above this level. The entire problem here is not that of mere mechanical obstruction at the esophagogastric junction; indeed, the obstruction resulting from peptic esophageal stricture or carcinoma is not associated with the tremendous dilatation seen in these patients. The term "megaesophagus" is sometimes used to designate this condition, and the underlying problem is the inability of the lower end of the esophagus to relax coordinately with the peristaltic contractions of the upper esophagus. There is evidence that the underlying difficulty is degeneration and atrophy of Auerbach's plexus of nerves similar to that found in Hirschsprung's disease of the colon. At any rate, cardiospasm does not result from a reflux of acid peptic juice into the esophagus.

Dilatation of the cardia will effect a cure in approximately two thirds of the patients having this condition, although repeated bougienage may be necessary.

Many operative procedures have been devised to correct achalasia. Most of these consist in enlarging the esophagogastric junction, and this inevitably results in a loss of the cardiac sphincter action with a resultant reflux of acid peptic juice into the esophagus and secondary peptic esophagitis. The Heller operation, described below,

appears to be the most satisfactory operation available. This consists in a longitudinal division of the muscle layers similar to the Fredet-Ramstedt procedure for congenital pyloric stenosis.

Technique of Esophagocardiomyotomy (Heller) (Fig. 369)

An indwelling esophageal tube is passed before operation. General endotracheal anesthesia is preferred. A transthoracic approach may be used; in most instances, however, an upper abdominal incision is preferred. An upper midline or left paramedian incision is satisfactory. Additional exposure can be obtained by removing the xiphoid or by using the median sternotomy extension as advocated by Wangensteen.

After exploration of the abdomen the stomach is retracted downward, and the left lateral (coronary) ligament of the liver is divided. This permits retraction of the left lobe of the liver out of the field. Use of the large retractor designed by Weinberg for use in vagotomy simplifies exposure.

The peritoneal reflection over the anterior esophagus is divided at a right angle



FIGURE 369. Heller operation for megaesophagus. *A*, Division of peritoneal reflection from the diaphragm to expose the esophagus The left lateral ligament of the liver has been divided and the liver retracted. *B*, Vertical incision through the muscular coats, but not the mucosa. An incision may be made in the stomach wall near the hiatus and the finger inserted to simplify placement of the incision. (R. Maingot: Abdominal Operations. New York, Appleton-Century-Crofts, Inc., 1948.)

to the esophagus, and by using the finger the esophagus can be freed around its entire circumference. The vagus nerves are left intact, and it may be advisable to place a ligature around the anterior vagus for identification purposes. A tape or piece of Penrose tubing is then passed around the esophagus for traction purposes. While maintaining downward traction on the esophagus, blunt finger dissection of the lower thoracic esophagus is carried out until approximately 10 cm. of the esophagus are mobilized below the diaphragm. A vertical myotomy incision is now done, carefully dividing the muscular coats, but not entering the mucosa. This allows the mucosa to bulge up between the cut edges of the muscularis. The incision is begun in the dilated portion of the esophagus about 8 cm. above the cardia. It is carried downward across the cardia and extends approximately 4 cm. on the stomach side of the cardia so that the entire length is approximately 12 cm. It may be helpful to make a small incision in the anterior wall of the stomach so that a finger can be inserted into the esophagus while making the incision into the muscularis over the finger. There may be a few small vessels present in the esophageal wall which must be divided and ligated to permit adequate bulging of the underlying mucosa.

When the myotomy has been completed, the stomach should be squeezed to express air and gastric juice back through the cardia to test for any possible inadvertent openings in the mucosal layer. If such an opening is found, it can be closed with a small interrupted suture. The area is then checked for hemostasis, and no attempt is made to reapproximate the peritoneal reflection. The abdomen is then closed in the conventional manner.

Nasogastric suction is maintained postoperatively for twenty-four to forty-eight hours, during which time nutrition is supplied by intravenous feedings. The tube is then removed, and liquids in small amounts are started by mouth. The feeding schedule is gradually increased to a regular diet.

BENIGN STRICTURE OF THE ESOPHAGUS

General Considerations

Benign strictures of the lower esophagus may follow trauma, infection, corrosion, peptic ulceration or chronic granulomas. Extensive cicatrizations of the esophagus are usually caused by chemical burns. Esophagogastrostomy is indicated in selected cases with stricture of the lower esophagus. Subtotal esophagectomy with high intrathoracic esophagogastric anastomosis is recommended by Sweet. Other authors have devised various types of esophagoplasties utilizing segments of small bowel or colon (Fig. 372). Intrathoracic operations are superior to any of the types of external esophagoplasty.

Technique of Transthoracic Esophagogastrostomy (Clark and Adams) (Fig. 370)

Positive pressure anesthesia is advised. An incision is made in the left eighth interspace. The lung is retracted to expose the costovertebral gutter. A section of the phrenic nerve is excised to ensure permanent paralysis of the left diaphragm. The mediastinal pleura is incised, and the esophagus is isolated beyond the extent of the stricture both above and below. The vagus nerves are preserved when possible. An incision 12 cm. long is made in the diaphragm from the esophageal hiatus toward the

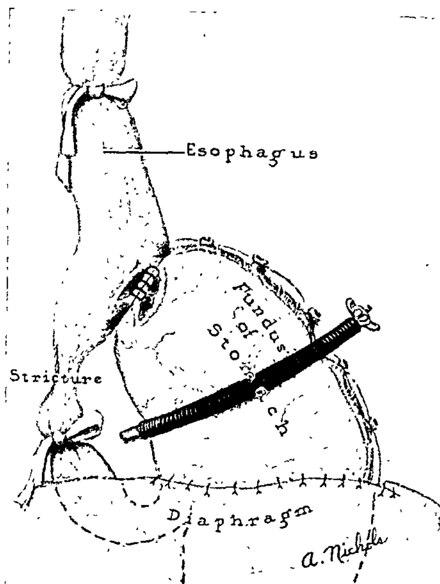


FIGURE 370. Technique of esophagogastrostomy for benign stricture of the esophagus Side-to-side anastomosis within the thorax between the esophagus and fundus of the stomach. (Redrawn from Clark and Adams. Ann Surg)

periphery. The stomach is mobilized and drawn into the thorax. A splenectomy may be done if it will facilitate mobilization of the stomach.

The site for anastomosis is selected just above the upper end of the stricture Umbilical tapes are tied around the esophagus to prevent wound soiling. A side-to-side anastomosis is made between the esophagus and fundus of the stomach. Two rows of sutures are used. To relieve tension on the suture line, the stomach is anchored to the pleura above the anastomosis. The wound in the diaphragm is closed about the stomach and sutured to its wall.

The chest wound is firmly closed, and the pleura is drained with a Pezzer catheter passed through the ninth interspace.

Small quantities of liquid are given by mouth on the fifth to the seventh post-operative day. A soft diet can usually be taken on the tenth to the twelfth day after operation. Antibiotics may be used both before and after operation. Pleural drainage is continued for five to seven days.

Technique of Esophagectomy and Intrathoracic Esophagogastric Anastomosis for Stricture (Sweet) (Fig. 371)

Intratracheal ether-oxygen anesthesia is advised.

The left eighth rib is resected, and the chest is opened along the rib bed. To

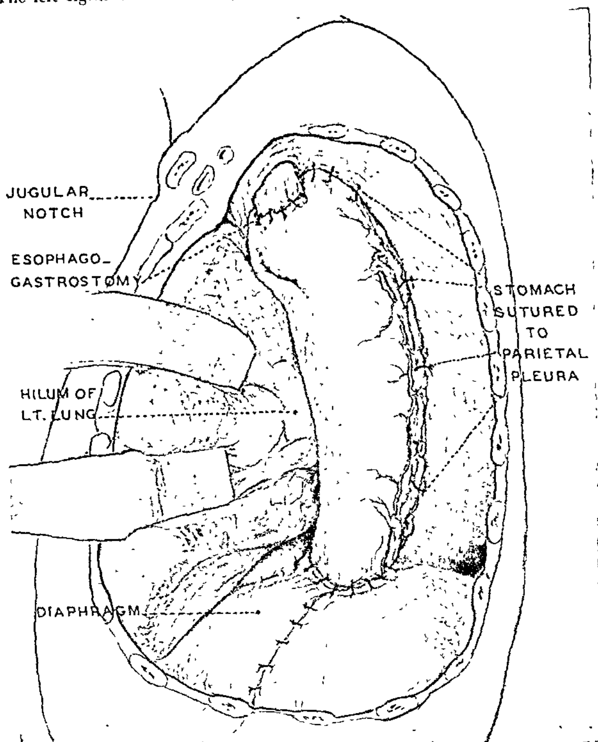


FIGURE 371 Technique of esophagectomy and intrathoracic esophagogastric anastomosis for stricture of the esophagus The anastomosis has been completed, and the anatomical relations of the chest viscera are shown The anastomosis lies opposite the jugular notch. The stomach lies in front and somewhat lateral to the aortic arch It lies behind the hilum of the left lung against the vertebral column and descending aorta The portion of the diaphragm surrounding the stomach has been sutured around the antrum, and the remainder of the diaphragmatic wound has been closed with interrupted sutures The stomach has been fixed in the chest by suturing it to the parietal pleura with fine silk. (Redrawn from Sweet: Surg., Gynec. & Obst., Vol 83.)

obtain adequate exposure, it may be necessary to divide one or more ribs posteriorly.

The esophagus is dissected free below the aortic arch. If the stricture extends above the aortic arch, the upper thoracic portion is freed through an incision in the pleura posterior to the thoracic portion of the left common carotid artery. As the esophagus is mobilized from behind the aortic arch, small arteries from the aorta, the bronchial arteries and esophageal branches from the descending portion of the aorta must be cut and ligated. The thoracic duct crosses the esophagus just above the aortic arch and should not be injured.

The stomach is mobilized through an incision in the diaphragm extending from the hiatus to near the costal insertion. The phrenic nerve is crushed to immobilize the diaphragm. The upper two thirds of the stomach is freed by dividing the gastrocolic ligament, the gastrolienal ligament and the gastrohepatic ligament. All vessels in the ligamentous attachments of the stomach are carefully ligated when severed. The left gastric artery is divided close to its origin from the celiac axis. This preserves its ascending and descending anastomosing branches. When dividing the attachments of the stomach to the diaphragm near the cardia, several small vessels, which are branches of the phrenic, pericardiophrenic and suprarenal arteries, must be severed and ligated.

The stomach is divided just distal to the cardia and closed with two rows of chromic catgut sutures reinforced with interrupted sutures of silk. The distal end of the esophagus is covered with a rubber dam to prevent soiling.

The freed esophagus is withdrawn from behind the arch of the aorta, divided above the stricture and anastomosed to the fundus of the stomach. A circular opening is made in the stomach slightly larger than the diameter of the esophagus. To this opening the severed end of the esophagus is anastomosed with three rows of interrupted sutures of fine silk. The mucosal layer is sutured so that the knots will lie within the lumen.

After completion of the anastomosis the stomach is anchored to the pleura with silk sutures. The edges of the diaphragm are sutured about the antral wall of the stomach. The remaining opening in the diaphragm is closed with two rows of silk sutures. A catheter is passed between the ribs for suction drainage. The chest wall is carefully closed in layers with silk sutures after expanding the lung.

RESECTION OF THE ESOPHAGUS FOR CARCINOMA

General Considerations

The surgical management of carcinoma of the esophagus has undergone many improvements during recent years. Even so, the long-term follow-up of patients having this disease has seen few five-year survivals. Because of anatomic location, lateral spread of esophageal carcinoma to contiguous structures occurs early in relation to the onset of symptoms. Likewise there is no opportunity to practice wide extirpation of the tumor as is possible in carcinoma arising in other portions of the gastrointestinal tract. There are, in addition, technical difficulties imposed by the fairly limited blood supply and the absence of a serosal covering present in most other portions of the gastrointestinal tract.

From the operative standpoint, carcinoma of the esophagus can be divided into three general categories based on the location: those lying in the cervical esophagus, those lying in the upper thoracic esophagus and those originating in the lower third of the esophagus and gastric cardia. Operations for those lesions originating in the cervical esophagus are described in Chapter 8. Those lesions lying in the upper thoracic region create special problems, since removal of the entire esophagus below the level of the lesion is necessary, thus creating a large defect which must be bridged. This defect can be bridged by widespread mobilization of the stomach into the thoracic cavity and anastomosis of the esophagus and stomach in this fashion. This can be done entirely through the left side of the chest, or it may be approached through the right side of the chest combined with an upper abdominal incision to free up and mobilize the stomach.

In addition to esophagogastrostomy for high lesions of the esophagus, numerous procedures utilizing segments of the colon or small intestine to bridge the defect left by removal of the esophagus have been devised. The basic principles involved in some of these procedures are outlined in Figure 372. Lesions of the lower thoracic esophagus and the gastric cardia have been treated by esophagogastrostomy since the first success-

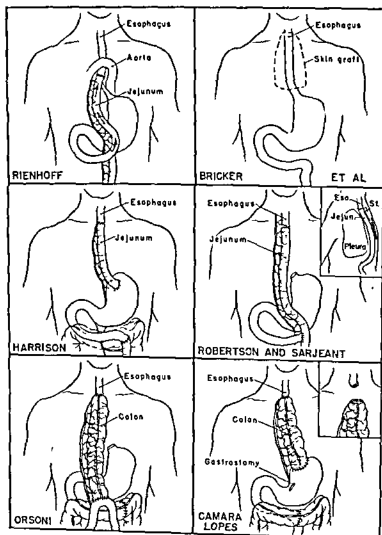


FIGURE 372 Diagrammatic illustration of some of the various methods used for replacement of the esophagus other than intrathoracic esophagogastric anastomosis (L. H. Camara-Lopez: J Thoracic Surg , Vol 25)

ful resection of such a case by Adams and Phemister in 1938. Use of the Torek type of operation, in which a subcutaneous skin tube is constructed external to the thoracic wall, has been discarded.

Dangers and Safeguards

Operations upon the esophagus for carcinoma are hazardous because of the advanced age of the patient, the frequently advanced stage of the growth, and the generally poor condition of the patient. In the groups selected for resection of the esophagus and esophagogastrostomy, the chief hazards are *open pneumothorax, surgical shock, hemorrhage, injury to vital mediastinal structures, cardiac failure, atelectasis,* and *infection* of the pleura, mediastinum or peritoneum. These dangers may be minimized by careful preoperative preparation of the patient. The state of nutrition should be improved as much as possible before operation by the judicious use of blood and plasma transfusions, intravenous administration of proteins, and feeding by mouth when possible. Transfusions and infusions should be given during the operation and the postoperative period until nourishment can be taken by mouth. By using antibiotics, both before and after operation, the incidence of infection may be reduced.

With modern methods of controlled intratracheal anesthesia and improved surgical technique, resection of the esophagus has become a reasonably safe procedure.

Technique of Combined Abdominal and Right Thoracic Esophagectomy and Esophagogastrostomy (Macmanus) (Figs. 373, 374)

Because of the position of the aorta on the left side, dissection and mobilization of esophageal lesions located in the mid- and upper thoracic portions of the esophagus are done more easily through the right thoracic cage. For this reason the right thoracic and upper abdominal approach as described by Lewis, Macmanus and others has been widely used for removal of esophageal carcinoma lying above the lower third. The operation consists of two parts: one, widespread dissection and mobilization of the stomach to allow it to be drawn high in the right thoracic cage; and, two, removal of the esophagus and lesion followed by anastomosis of the esophagus and mobilized stomach. This may be accomplished through a right thoracoabdominal incision or through two separate incisions. In general, if the lesion is located as high as the aortic arch, separate incisions are preferred, since a high thoracic incision with removal of the fifth rib to permit the anastomosis to be made high in the thoracic cavity is necessary. If indicated, the procedure may be done in stages. The abdominal portion is done as a first stage and the thoracic portion done several days subsequently. However, with good supportive measures and anesthesia, division of the operation into separate stages is rarely necessary.

General endotracheal anesthesia is essential. In general, the abdominal portion of the procedure should be done first, since the presence of nonresectable abdominal metastases may contraindicate completion of the operation. If preferred, the abdominal and thoracic portions of the operation can be done through separate fields and the patient's position changed and the field redraped between the two. In most instances, however, both fields can be prepared as a single field and the position of the patient altered slightly between the two stages by the use of sand bags and by tipping

the table laterally. An upper midline or left paramedian incision is made. Exploration of the abdomen is carried out with careful search for metastases in the liver or preaortic or periesophageal nodes. The presence of liver metastases or nonresectable lymph nodes in general contraindicates completion of the operation.

Attention is then directed to the gastrocolic omentum, and this structure is divided, taking care to preserve the right gastroepiploic artery and its branches to the stomach. The greater curvature is thus mobilized from the region of the antrum to the cardia. As the region of the fundus is approached, division of the left gastroepiploic vessels and the vasa brevia between the spleen and the stomach is necessary. The spleen may be removed to facilitate exposure and mobilization of the stomach; however, this is not necessary in most instances. Care must be taken in clamping and ligating the short gastric arteries to avoid injury to the spleen. Use of suture ligatures on the gastric side of these divided vessels is indicated, since traction applied to the stomach from above through the thoracic portion of the incision may result in slipping of plain ligatures in this region. The stomach is then turned upward and the left gastric artery divided and secured with suture ligatures on both sides. This artery should be divided as close to its origin as possible, leaving collateral channels for blood from the right gastric artery. The gastrohepatic mesentery is then divided through its entire length. Exposure of the abdominal esophagus is facilitated by division of the coronary ligament of the liver. This is an avascular structure, and its division permits retraction of the left lobe of the liver well out of view. The peritoneal reflection from

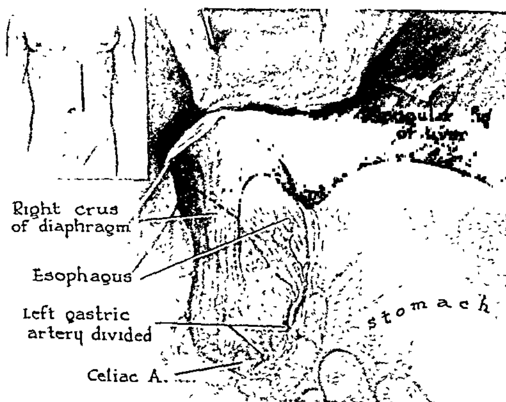


FIGURE 373 Combined abdominal and right thoracic esophageal resection An upper abdominal incision is made as shown in the inset. When the greater and lesser curvatures of the stomach have been mobilized, exposure of the esophagus is facilitated by division of the triangular ligament of the liver, as shown When the esophageal hiatus is of normal size, this aperture is enlarged by division of the right crus of the diaphragm near its insertion, as illustrated by the dotted line. (J. E. Macmanus, in George T. Pack: Cancer of the Esophagus and Gastric Cardia. St. Louis, C. V. Mosby Company.)

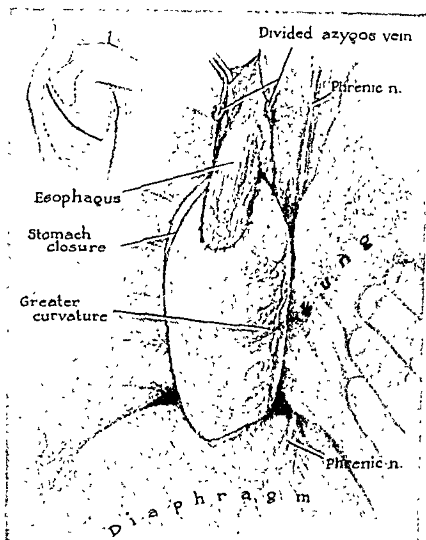


FIGURE 374. Combined abdominal and right thoracic esophageal resection (*concluded*). Inset shows a right posterolateral incision. Appearance after removal of the lesion and lower esophagus and completion of the esophagogastric anastomosis is illustrated. (J. E Macmanus, in George T. Pack: Cancer of the Esophagus and Gastric Cardia. St. Louis, C. V. Mosby Company, 1945)

the diaphragm over the anterior portion of the esophagus is divided transversly, thus permitting ready mobilization of the esophagus. Several anastomotic vessels in this region must be clamped and ligated. In the presence of a large diaphragmatic hiatus, sufficient room may be present to allow the stomach to be mobilized into the chest through this region without further enlargement. In the presence of a hiatus of normal size, however, enlargement of this opening by transecting the right crus of the diaphragm near its margin is necessary. Care must be exercised not to injure the thoracic duct. When the crus is divided, bleeding may be encountered from branches of the right inferior phrenic artery.

When the dissection has been completed, the entire stomach from pylorus to cardia is mobilized, the blood supply being derived from the right gastric and right gastroepiploic vessels. Before closing the abdomen it is advisable to do a pyloroplasty, since delayed emptying of the stomach due to gastric atony will result from the vagotomy which of necessity accompanies the operation This can be done by simple pyloromyotomy or, if preferred, by a Heineke-Mikulicz type of pyloroplasty. The abdomen is then closed in routine fashion.

Thoracic Portion of Operation. With the patient lying on the left side a classic

right posterolateral thoracotomy incision is made and the pleural space entered through the bed of the excised rib. The rib to be excised will depend somewhat upon the height of the lesion, but usually the fifth or sixth rib will be most satisfactory. Exposure can be increased by transecting the rib above and/or below that excised near its posterior margin. The lung is retracted medially and the extent of the lesion evaluated by palpation and visualization. In all but low-lying lesions it is necessary to ligate and divide the azygos vein. The mediastinal pleura is then opened from a point 3 to 4 inches above the lesion down to the diaphragm below. Mobilization of the lesion by blunt and sharp dissection is then carried out, taking care to avoid injury to the aorta and to the pulmonary vessels. When the mass has been dissected free, the esophagus lying below the lesion is mobilized, taking care to clamp and ligate arterial branches from the aorta to the esophagus. It is then possible to deliver the stomach into the chest. The stomach is divided just below the cardio-esophageal junction and closed with a running layer of catgut reinforced with interrupted silk sutures. The lower esophagus and mass are then turned upward and the level of anastomosis selected. If possible, this should extend at least 3 inches above the gross lesion.

A site is then selected in the fundus of the stomach for incision of the stomach and completion of the anastomosis. An incision approximately the size of the diameter of the esophagus is made. A posterior layer of mattress silk sutures between the serosa of the stomach and the muscularis layer of the esophagus is then placed. Placement of these sutures is facilitated if the sutures are not tied down until all have been placed. The posterior wall of the esophagus is then transected, and the inner layer of sutures, consisting of fine interrupted silk, is placed through all layers of the stomach and esophagus. When this layer of sutures has been completed, the anterior wall of the esophagus is transected and the inner layer of sutures carried around anteriorly. These are placed so that the knots will lie on the inside of the lumen. The outer layer of mattress sutures between the stomach and the esophagus is then completed. The fundus of the stomach is sutured to the mediastinum and thoracic pleura above and to the diaphragm below to take all tension away from the anastomotic line. The chest is then irrigated thoroughly, and an intercostal tube is brought out through a stab wound and placed beneath waterseal drainage. The lung is re-expanded and the chest wall closed in layers with interrupted silk sutures.

Postoperatively, the stomach is kept deflated by means of a soft nasogastric tube passed through the anastomotic line for approximately forty-eight hours. After this the tube is removed and liquids in small quantities by mouth begun. The intercostal tube is removed in thirty-six to forty-eight hours.

Technique of Resection of Midthoracic Esophagus for Carcinoma (Adams) (*Figs. 375, 376*)

Intratracheal anesthesia is used. An incision is made over the left eighth rib from the costal margin to angle of the rib. It is usually desirable to resect the eighth rib, but this step is not always necessary. It is often advisable to divide the fifth, sixth and seventh ribs near the angle posteriorly for adequate exposure. The wound is held open with a rib spreader, and the lung is protected with a gauze pack and retracted. A careful exploration of the tumor is made to determine its resectability. The mediastinal pleura is incised over the esophagus posterior to the hilum of the lung up to

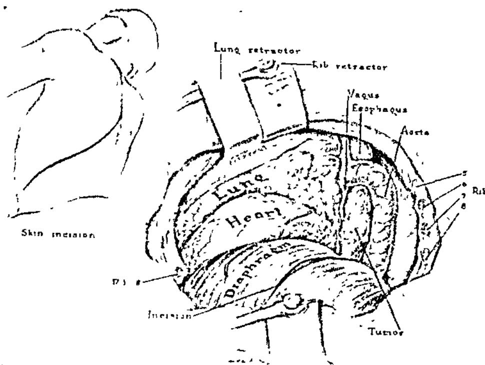


FIGURE 375. Technique of resection of the midthoracic esophagus for carcinoma. To the left is shown the type of incision made over the left eighth rib. In the drawing to the right the chest wound is opened, showing the viscera involved in the dissection (Adams. S. Clin. North America, Vol 26)

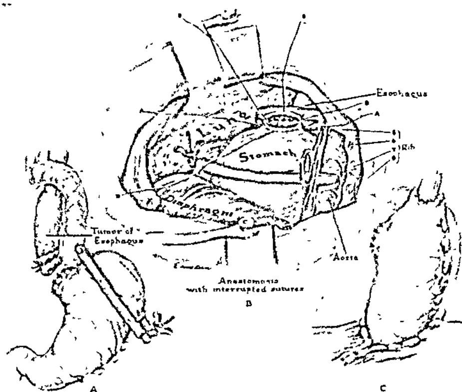


FIGURE 376 Technique of resection of the midthoracic esophagus for carcinoma. *A*, The lower *two thirds of the esophagus and the upper four fifths of the stomach have been mobilized*, the esophagus has been divided and the cardia closed *B*, Rubber-shod clamps have been placed on the stomach and esophagus in preparation for the anastomosis The 2 posterior rows of interrupted sutures have been placed. *C*, The anastomosis has been completed just above the level of the aortic arch, and the diaphragm has been sutured to the stomach (Adams. S. Clin North America, Vol. 26)

the arch of the aorta. The left pulmonary ligament is divided and ligated when necessary. After dissecting the tissues free over the esophagus, the extent of the growth is carefully explored. If tumor tissue invades the main bronchus or inferior pulmonary vein or is adherent to the arch of the aorta, the operation should probably be abandoned. If adhesions to these vital structures can be divided without too much hazard and there are no distinct lymph node metastases, the operation should be continued.

The esophagus is separated from its bed from the diaphragm to the aortic arch. The right thoracic cavity may be opened during the dissection. The diaphragm is then incised from the hiatus outward to near its costal attachments, and the liver and upper stomach region are explored for metastases. The phrenic nerve is crushed to immobilize the diaphragm. The fundus and greater curvature of the stomach are mobilized by cutting and ligating the gastrolienal ligament, the left gastroepiploic vessels, the vasa brevia and the gastrocolic omentum as far as the pylorus. Injury to the right gastroepiploic vessels should be avoided. The spleen may be removed if necessary to facilitate exposure and mobilization of the stomach into the chest. The cardia and lower end of the esophagus are next freed. Small branches from the suprarenal, inferior phrenic and pericardiophrenic vessels are cut and ligated. The gastrohepatic ligament is divided, and the gastric vessels are cut and ligated near the origin of the left gastric artery at the celiac axis (Fig. 377). Any lymph nodes found along the lesser curvature of the stomach and near the cardia should be removed. The fundus of the stomach can then be drawn upward to the apex of the chest.

The stomach is divided between clamps just below the cardia, and the esophageal end is covered with rubber tissue or a glove to prevent soiling. The stomach is closed with two rows of catgut sutures reinforced with a row of interrupted sutures of silk or cotton. After the stomach and lower esophagus have been mobilized the pleura above the aorta is incised, and the upper end of the esophagus is freed. The esophagus

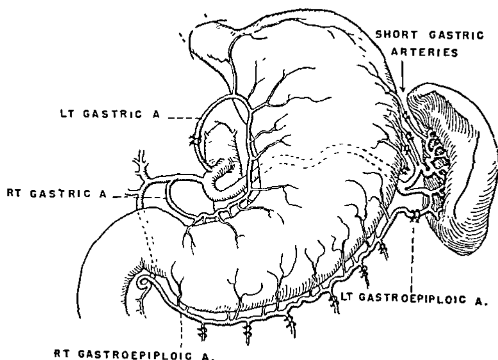


FIGURE 377 Technique of mobilization of the stomach. The points of division and ligation of vessels to safely and adequately mobilize the stomach are indicated. Trauma to the stomach must be avoided, and its marginal blood supply must be carefully preserved.

is withdrawn from beneath the aortic arch. The thoracic duct above the aortic arch should be identified during the dissection and protected. If the duct is accidentally wounded or severed, it should be ligated.

When the upper limits of the tumor in the esophagus do not extend as high as the aortic arch, the anastomosis may be done below the arch without mobilization.

A circular incision is made in the fundus of the stomach approximately the size of the diameter of the esophagus. A rubber-shod clamp may be placed on the stomach and a right-angled clamp on the esophagus to prevent spillage during the operation. By careful aspiration, spillage from the esophagus and stomach can be controlled without clamps. Sweet uses three rows of sutures for the anastomosis. The posterior serosa and muscularis are united with interrupted silk sutures before the mucosa is opened. The mucosa is sutured with silk as a separate layer. The esophagus is then divided, and the anastomosis is completed with three rows of anterior sutures.

The stomach is anchored in the upper chest with silk sutures which attach it to the parietal pleura. The medial portion of the diaphragm is sutured around the antrum of the stomach, and the lateral portion is closed with two rows of silk sutures. A catheter is placed between the lower ribs for suction drainage. The ends of the severed ribs are sutured, and the chest wound is closed in layers with silk. The lung is expanded as the chest is made airtight by the wound closure. Liquids in small quantities may be given by mouth on the fourth or fifth postoperative day.

Technique of Resection of the Lower Esophagus and Cardia for Carcinoma (Humphreys) (Figs. 378, 379, 380)

Intratracheal anesthesia is used. Since many carcinomas involving the lower end of the esophagus, cardia, and fundus of the stomach are inoperable, an abdominal incision is made first for exploration. This incision extends from the costal margin at the level of the eighth interspace to a point just to the right of the midline about 2 cm. above the umbilicus. Through this incision the abdomen can be adequately explored for metastases and to determine the size, location and character of the growth. If the tumor is removable, the incision is extended through the costal cartilage along the eighth interspace to the posterior axillary line. By breaking the operating table at the lower chest margin, a wide exposure of the subphrenic region is obtained.

The diaphragm is incised from its attachment between the eighth and ninth ribs to the hiatus, and the esophagus is dissected free to a point suitable for anastomosis. The greater curvature of the stomach is mobilized by dividing the gastrolienal ligament, the vasa brevia and the gastrocolic ligament as far toward the pylorus as necessary. Small vessels about the cardia will require section and ligation. To free the lesser curvature, the gastrohepatic ligament is divided and the left gastric artery is cut and ligated near its origin at the celiac axis. The blood supply to the stomach must be carefully preserved (Fig. 377). Lymph nodes in the region of the celiac axis should be removed. If necessary, the spleen and great omentum may be removed.

As much of the stomach as necessary is resected. The stomach is divided between clamps, and the lower segment is closed with three rows of sutures. An anastomosis may be made between the esophagus and the open end of the stomach, but it is preferable to make the anastomosis between the cut end of the esophagus and a new opening made in the stomach wall. The esophagus is first sutured to the stomach wall

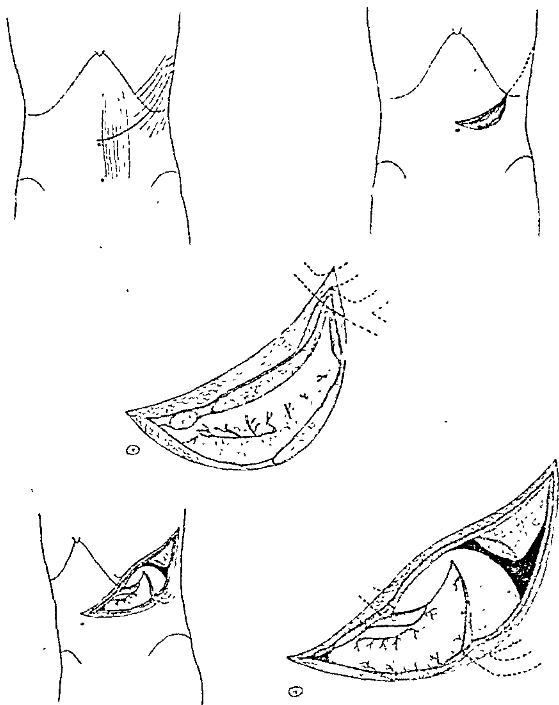


FIGURE 378. Technique of the abdominothoracic approach for resection of the lower esophagus and cardia. The illustrations show the line of the abdominothoracic incision, the abdominal incision opened for exploration, and the completed abdominothoracic incision with incision in the diaphragm. (Humphreys: Ann. Surg., Vol 124, J B. Lippincott Company.)

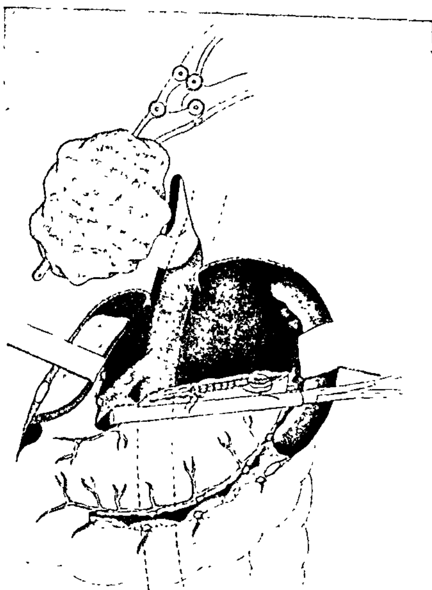


FIGURE 379. Technique of abdominothoracic approach for resection of the lower esophagus and cardia (*continued*). The stomach has been mobilized and divided between clamps The lower segment of the stomach is completely closed with 2 rows of sutures, and the upper segment is covered with gauze to protect against infection. (Humphreys· Ann Surg , Vol 124, J. B. Lippincott Company)

above the site of anastomosis. The involved esophagus is then removed, and a vertical incision of suitable size is made through the stomach wall. An anastomosis is made with sutures placed through all layers of the stomach and esophagus, and mattress sutures are used to fold the anterior gastric wall over the anastomosis and anchor it to the pleura.

The medial end of the opening in the diaphragm is sutured around the stomach, and the remainder of the wound is closed with two rows of silk sutures. A tube is passed through the ninth interspace for suction drainage. The abdominal and chest wounds are closed in layers with silk. Before the chest is closed, the lung is expanded. Garlock recommends a Witzel jejunostomy for feeding before the abdominal incision is closed.

Tumors of the fundus of the stomach may readily be resected, or a complete gastrectomy may be done through the abdominothoracic incision described.

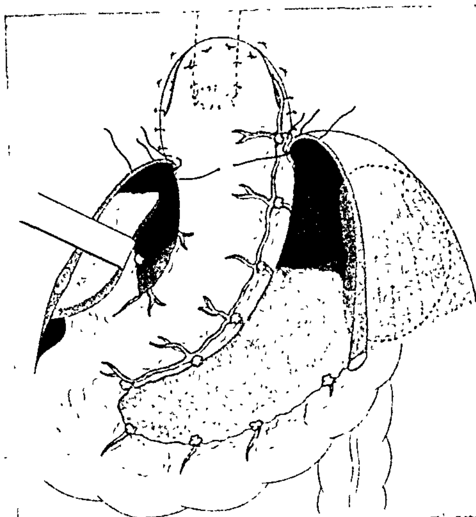


FIGURE 380 Technique of the abdominothoracic approach for resection of the lower esophagus and cardia (*concluded*). The esophagogastrostomy has been completed Note that the esophagus is sutured to the stomach wall above the anastomosis, and the stomach wall is folded upward to cover the anastomosis. The stomach is sutured to the parietal wall for anchorage. (Humphreys: Ann. Surg., Vol. 124, J. B. Lippincott Company)

Operations upon the Stomach

GENERAL PRINCIPLES

Anatomy

The moderately distended stomach is a pear-shaped organ having an average capacity of 1 to 2 liters. The size, shape and position of the stomach are variable in different people and under various disease conditions. Its most fixed point is at its junction with the esophagus, from which it hangs suspended. This point is approximately located beneath the left seventh costal cartilage, about 2 cm. from the sternal margin opposite the eleventh dorsal vertebra, and 10 cm. beneath the surface of the anterior abdominal wall. The pylorus lies under the edge of the liver in the median line or just to the right of the median line on a level with the first lumbar vertebra. If the liver is high, the pylorus lies against the anterior abdominal wall. The pylorus is identified at operation by palpation of the pyloric ring and by a constant transverse pyloric vein.

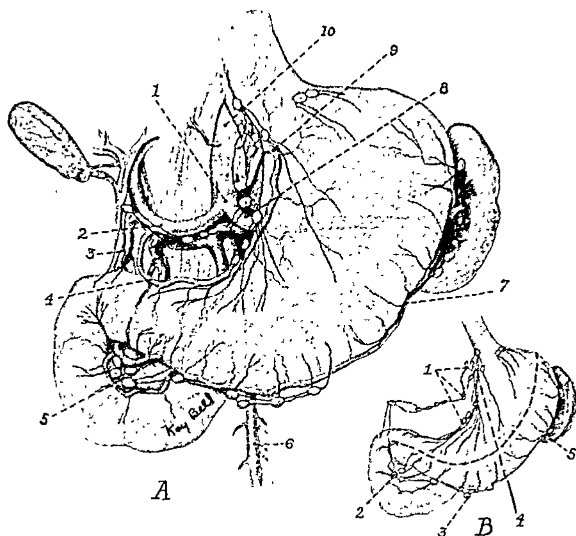


FIGURE 381. Anatomy of the stomach and duodenum, showing locations of principal arteries and lymph nodes. *A: 1*, celiac axis; *2*, hepatic artery; *3*, gastroduodenal artery, *4*, right gastric artery; *5*, right gastroepiploic artery, *6*, mesenteric artery; *7*, left gastroepiploic artery; *8*, splenic artery; *9*, left gastric artery; *10*, aorta. *B 1*, superior gastric lymph nodes; *2*, subpyloric lymph nodes; *3*, inferior gastric lymph nodes; *4*, lines separating lymph drainage fields of stomach; *5*, splenic lymph nodes.

Anteriorly, the stomach is in relation to the diaphragm, liver and abdominal wall; posteriorly, to the transverse mesocolon, aorta, thoracic duct, solar plexus, vena cava, crura of the diaphragm, pancreas, adrenal body, kidney and spleen; above, to the gastrohepatic omentum, liver and diaphragm; and below, to the transverse colon, gastrocolic omentum and gastrosplenic ligament.

The arterial supply is well shown in Figure 381. The veins follow the course of the arteries. Lymphatic nodes are found in greatest numbers in the region of the pylorus. They are usually identified at operation in the gastrohepatic and gastrocolic omenta near the stomach wall along the greater and lesser curvatures. Nodes are infrequent along the middle portion of the greater curvature and in the region of the fundus.

Dangers and Safeguards

A *careful preoperative study and preparation* of patients requiring major operations

upon the stomach is essential to prevent a high operative mortality rate. Disturbed physiology incident to gastric and duodenal disease can in large measure be corrected before elective operations. The possibility of dehydration, a loss of essential gastrointestinal secretions by vomiting, dilatation and loss of tone of the stomach wall, and disturbed nutrition are all important problems for the surgeon.

A decrease in the blood chlorides and an increase in the nonprotein nitrogen and carbon dioxide-combining power are indications for liberal administration of sodium chloride or Ringer's solution before operation. Dextrose in 5 per cent solution should be added to the chloride solution to furnish glycogen to the liver and add calories.

Stomachs with obstructive lesions may be dilated. Repeated *gastric lavage* or *continuous gastric suction and decompression* with the Wangensteen type of apparatus for three or four days will reduce the size of the stomach, reduce infection and edema of its walls, and increase its muscle tone and blood supply. This is an important safety factor in the reduction of technical difficulties of operation and promotion of prompt healing. Ulcerating tumors of the stomach associated with an absence or decrease in hydrochloric acid are usually infected. Careful cleansing of the stomach reduces both infection and edema incident to such lesions. In the absence of hydrochloric acid in the gastric secretion, a dilute solution of 0.5 to 1 per cent hydrochloric acid may be used to lavage the stomach before operation.

Transfusions for secondary anemia should be given before and after major stomach operations. If an operation is prolonged, *intravenous fluids* and a transfusion should be administered during the operation.

Postoperative infections may be reduced to a minimum by proper preparation of the stomach before operation and by *careful technique* to avoid peritoneal and wound soiling during the operation. An excellent operation, from the technical standpoint, may prove fatal if attention is not given to immediate *postoperative treatment*. Water and essential electrolytes are indicated in all cases and transfusions in many. Continuous gastric suction after operation for two to three days will prevent distention of the stomach, reduce edema and promote healing. The use of antibiotics both before and after operation will aid in controlling infections.

The importance of *nutritional disturbances* associated with diseases of the stomach and duodenum has been emphasized by Maddock. Vitamin and protein deficiencies must be taken into account when estimating the operability and recovery of a patient whose pathologic processes have interfered with normal nutrition. It is, therefore, essential that food containing such important factors as vitamins and proteins be given to the depleted patient as soon as his disease and postoperative condition will permit.

Gastrointestinal Suture (Fig. 382)

Gastrointestinal suture consists for the most part in the apposition of two portions of the gastrointestinal tract to re-establish continuity of flow of the contents normally carried by the parts being joined. The fundamental objective is the establishment of a watertight nonleaking anastomosis with the proper approximation of surfaces that will heal permanently in a short time without stricture formation. The sutures are often used to prevent bleeding from the cut surfaces of the substance tissues being anastomosed. In order to prevent leakage it is desirable to invert the mucous mem-

brane without inverting excess tissue which might result in the formation of a diaphragm inside the lumen with consequent obstruction to the flow of contents.

Many different types of sutures and methods of performing intestinal anastomosis have been devised. Some of these are described in Chapter 3. Anastomoses may be of the open or closed variety, depending upon whether the lumen of the tissue being anastomosed is opened during the procedure; interrupted sutures or running sutures or a combination of the two may be used; the anastomosis may be made in one, two or three layers, and the sutures may be of the absorbable or nonabsorbable variety, or a combination of both may be used. Many special clamps and mechanical devices have been developed to facilitate the procedure.

It is therefore obvious that the fundamental objectives in doing intestinal anastomoses can be met by various methods when done properly. Several different meth-

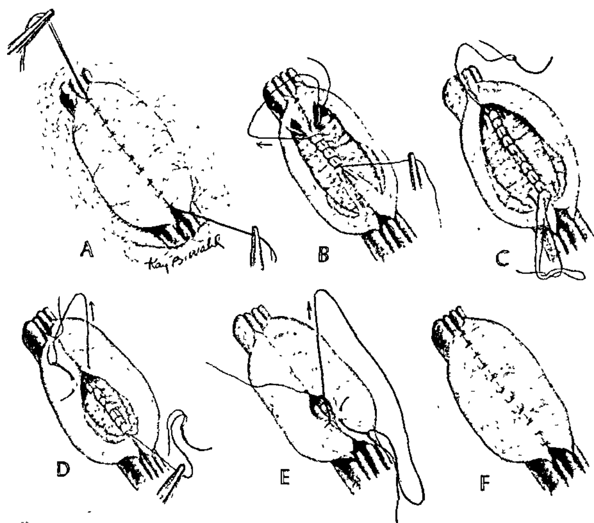


FIGURE 382 Gastrointestinal suture This technique is suitable for gastrointestinal anastomosis of any type *A*, Posterior row of interrupted silk sutures. *B*, The lumen is open on both sides, and the inner row of continuous, locked catgut suture is started at the midpoint posteriorly. When the corner is reached, the suture is tied *C*, With a second suture a continuous locked suture is started at the midpoint posterior and continued in the opposite direction The two ends are tied together at the midpoint. *D*, By using the first suture the inner layer is continued around the corner and anteriorly as a continuous inverting stitch to the midpoint anteriorly. *E*, The second suture is continued around the corner anteriorly in similar fashion until the 2 sutures meet in the midline anteriorly. These are tied, thus completing the inner layer *F*, The outer layer of sutures, consisting of interrupted silk, is completed on the presenting side of the anastomosis.

ods of anastomosis are described in the various operations discussed in this chapter. The technique of anastomosis most widely used in this country consists in an open type of anastomosis, using an inner layer of running absorbable catgut reinforced with an outer layer of interrupted nonabsorbable sutures of silk or cotton. The inner layer of continuous catgut produces a watertight hemostatic suture line with inversion of the mucous membrane. The outer layer of nonabsorbable sutures which penetrate the seromuscular layer only add permanent strength to the suture line, ensure eversion of the mucosa and produce apposition of the serosal surfaces to form a tight union as quickly as possible.

Fine taper-point noncutting needles are desirable, swaged to the end of the needle so that as small a hole as possible is produced when the needle is passed through the wall of the intestine being sutured. All types of suture materials swaged to a wide variety of needles are available. Needles of the French eye type which can be threaded from the end, thus avoiding a large eye at the end of the needle, are preferred by many for gastrointestinal suturing.

The technique of anastomosis illustrated and described in Figure 382 has been found suitable for use throughout the intestinal tract.

GASTROTOMY

General Considerations

Gastrotomy is frequently indicated for the removal of foreign bodies, rarely indicated for the removal of small benign tumors, and occasionally indicated for stomach exploration.

The danger of opening the stomach is usually not great if done without peritoneal soiling. However, such foreign bodies as phytobezoars and trichobezoars are always grossly infected and associated with gastritis and thus require more than the usual care to prevent soiling of the peritoneum during their removal.

Postoperative complications are not common unless the condition for which the operation is done is associated with complicating factors.

Technique of Gastrotomy

A left paramedian incision will usually permit ample exposure. The operative field is protected by moist gauze. The type of incision into the stomach depends upon the size and location of the foreign body or tumor. A longitudinal incision through the anterior wall midway between the greater and lesser curvatures causes little bleeding, may be enlarged as indicated, and is easily closed. As the incision is made, the stomach wall is lifted with forceps to prevent spilling of its contents. Suction should be used freely to prevent soiling. Bleeding points may be controlled with small clamps, The wound margins are caught with Allis forceps to avoid injury to the mucosa as much as possible.

After removal of the foreign body or tumor the stomach wound is closed with a continuous suture of fine chromic catgut in the mucosa, a second row of fine catgut in the muscle and serosal margin, and a third row of interrupted Lembert sutures of fine silk to invert the wound edges and carefully approximate the peritoneal surfaces. The abdominal wall is closed without drainage.

CLOSURE OF PERFORATING GASTRIC WOUNDS

General Considerations

Wounds of the stomach are usually due to knives, firearms and sharp or blunt instruments. The stomach may be torn by crushing injuries. It is an interesting fact that wounds of the stomach tend to heal spontaneously more frequently than wounds of any other portion of the gastrointestinal tract. If a wound of the stomach is suspected, the abdomen should be explored. Injury to other structures may be present.

Technique of Operation

A left paramedian or left transrectus incision is made. Any exudate about the stomach should be removed by sponging and suction. If the gastric wound is already sealed by tight adhesions, these should be freed carefully to prevent peritoneal soiling. If there is any bleeding, the injured vessels should be isolated and ligated. The wound in the gastric wall is closed with three rows of sutures smoothly approximating the serosal surfaces. The posterior surface of the stomach is approached by opening the gastrohepatic or gastrocolic omentum. This is sometimes technically difficult, and in rare cases the wound may be more readily exposed through an enlargement of the anterior gastric wall wound. Suturing a posterior wound through an anterior incision may be aided by the hand passed through an opening in the gastrohepatic omentum. Through-and-through mattress sutures placed from the mucosal side, reinforced by interrupted sutures through the wound margins, make a satisfactory closure. Drainage of the lesser peritoneal cavity is advisable. Gastric suction and decompression are indicated for two to three days following operation.

GASTROSTOMY

General Considerations

Gastrostomy is most frequently done as a palliative measure to prevent starvation in incurable malignant disease of the esophagus. Life expectancy in such patients is usually a few weeks or months. Permanent benign strictures may demand a permanent gastrostomy. Temporary gastrostomy to ensure intestinal decompression when nasogastric suction cannot be used may be indicated when the abdomen is opened for other reasons.

In general, there are two types of gastrostomy: those having a tract lined with serosa and those having a fistula lined with gastric mucosa. The latter is desirable if gastric feeding is to be permanent. Serosal-lined fistulas tend to close spontaneously more readily than those lined with mucosa. If a gastric fistula is to be permanent, it should be so designed that leakage from the stomach is minimized to prevent excoriation of the skin by gastric secretions.

Dangers and Safeguards

Most patients requiring a gastrostomy are usually much depleted by starvation and dehydration. Preoperative preparation of the patient with dextrose and sodium

chloride solutions and the use of transfusions are usually necessary. Local anesthesia is advisable in the majority of cases. In the more elaborate types of operation a gas or spinal anesthetic is preferable. The operative mortality rate is low if the patient is properly prepared and soiling of the peritoneum and wound is avoided. The stomach must be carefully differentiated from the colon.

Technique of the Witzel Gastrostomy (Fig. 383)

A high left paramedian or transrectus incision is made. The anterior wall of the stomach toward the fundus is exposed and controlled by Allis forceps. A purse-string suture of fine chromic catgut is placed, and through a stab wound within the circle of the suture a no. 16 or 18 French catheter is inserted 5 to 6 cm. A Pezzer type of catheter may also be used. The catheter is then buried in the stomach wall a distance of 6 to 8 cm. with a row of Lembert sutures. *The last suture should transfix the wall of* the catheter to hold it in position. A stab wound is then made at the margin of the left rectus muscle near the costal margin, and the clamped catheter is drawn through. The stomach wall is sutured to the peritoneum about the margin of the stab wound around the tube. The abdominal wound is closed without drainage. The catheter is fixed to the abdominal wall with adhesive tape or, better, by a larger tube fitting snugly over the catheter near its exit, through which a safety pin may be passed to aid in fixation to the abdominal wall. This type of gastrostomy will usually close promptly if the tube is removed.

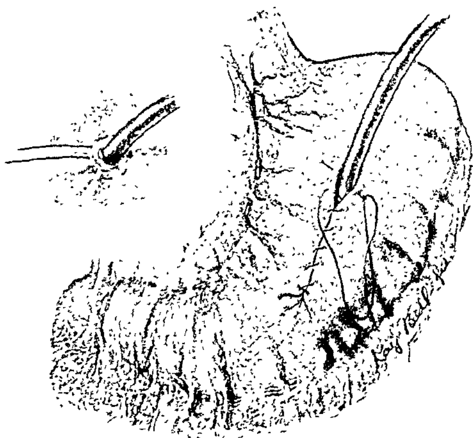


FIGURE 383 Technique of the Witzel gastrostomy

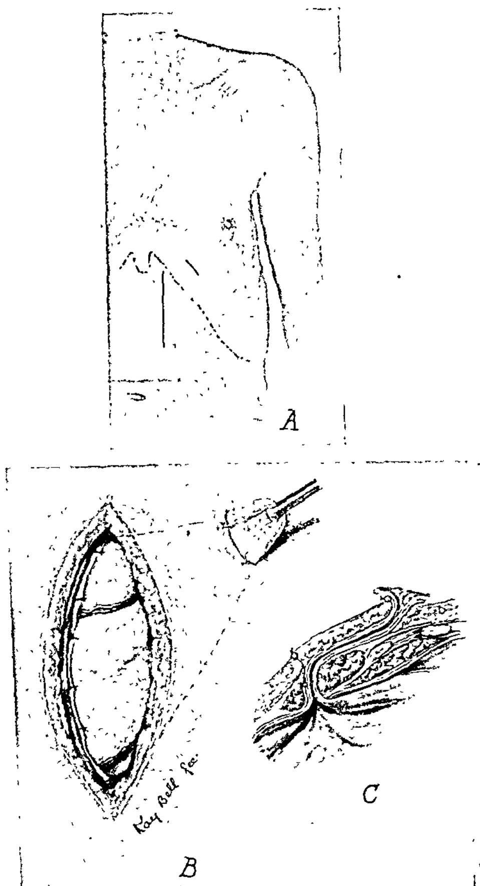


FIGURE 384 Technique of the Ssabanajew-Frank gastrostomy. *A*, High left rectus incision. Sla incision at costal margin *B*, Cone of stomach wall drawn beneath skin and through small incisi and sutured. Posterior sheath of rectus muscle sutured to stomach. *C*, Cross section of stomach w drawn through both incisions.

Technique of the Ssabanajew-Frank Gastrostomy (Fig. 384)

A high incision 8 cm. long is made through the midportion of the left rectus muscle. A second incision is made through the skin 2 cm. long just above the left costal margin in the midclavicular line. The two incisions are connected by blunt dissection beneath the skin. A cone of anterior gastric wall as near the fundus as possible is drawn through the first incision beneath the skin and out through the second incision and attached to the skin with silk sutures. This step may be modified by passing the cone of stomach beneath the anterior rectus sheath or through the rectus muscle. The posterior rectus fascia with the peritoneum is sutured to the stomach wall. The muscle and anterior fascia are closed snugly about the stomach, and the skin is closed over the stomach. The stomach may be opened at once and a purse-string suture placed

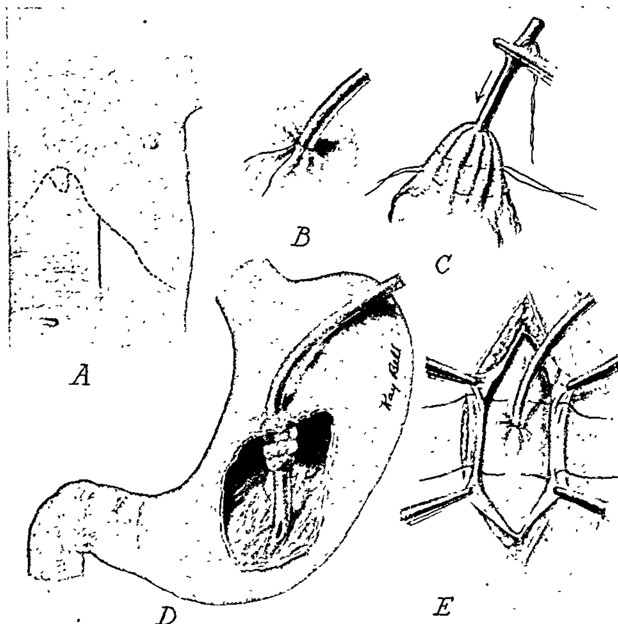


FIGURE 385. Technique of the Stamm gastrostomy. *A*, Incision through upper left rectus muscle. *B*, Purse-string suture in stomach wall A stitch is passed through the wall of catheter for fixation *C*, Two additional purse-string sutures placed in stomach wall about 1 cm. apart. *D*, Window in stomach to show inversion of wall with purse-string sutures. *E*, Fixation of stomach wall to peritoneum by sutures.

about an inserted catheter to prevent leakage. The catheter should be fixed to the abdominal wall.

Technique of the Stamm Gastrostomy (Fig. 385)

The stomach is exposed through a left rectus incision near its outer border just below the left costal margin. The anterior stomach wall as far from the pylorus as possible is lifted into the wound with Allis forceps. A small purse-string suture is placed, and, within this suture, a stab wound is made in the gastric wall large enough to admit a no. 16 or 18 French catheter. The use of a Pezzer type of catheter will aid in preventing the escape of the catheter from the stomach. The catheter is passed into the stomach about 5 cm. and fixed by the purse-string suture, one end of which transfixes the outer wall of the catheter. Chromic catgut or fine silk may be used. Two additional purse-string sutures are placed in the stomach wall through the serosa and muscularis about the tube 1 cm. apart. The stomach wall is then invaginated as an inverted cone into the stomach cavity. By tying the purse-string sutures, a serosa-lined tube is made in the stomach wall. If sufficient stomach wall is available, the purse-string sutures may be increased to three or four, thereby lengthening the fistula. The last purse-string suture placed is fixed to the tube by transfixing its outer wall.

The stomach wall about the tube is sutured to the peritoneum, and the abdominal wound is closed. This procedure may be modified by passing the tube through a small stab wound near the left costal margin. The tube should be fixed to the skin.

Technique of the Janeway Gastrostomy (Fig. 386)

Local anesthesia is usually satisfactory. An incision 8 cm. long is made through the middle or outer half of the left rectus muscle, extending downward from the costal margin. The anterior stomach wall is pulled a little to the right into the wound so that the plastic tube to be constructed may be placed in the body of the stomach away from the pylorus. The portion of the stomach delivered through the wound is protected with moist gauze pads.

A rectangular flap about 2.5 cm. wide and 5 cm. long, with its base toward the greater curvature and its free end at the lesser curvature, is outlined by placing Allis clamps. The first incision is made at the free end of the outlined flap parallel to the lesser curvature. The edge of the wound is controlled by an Allis clamp placed in the center of the incision. From the ends of this transverse incision the lateral incisions are extended to form the plastic flap of stomach wall. The flap is retracted by Allis clamps.

After controlling all bleeding with fine plain catgut ligatures, a no. 14 or 16 French catheter is inserted through the stomach opening, and closure is begun at the Allis clamp marking the middle of the transverse incision. The mucosa of the stomach wound and plastic flap is first closed with fine chromic catgut placed as a lock-stitch. The serosal layer is closed with interrupted Lembert sutures of fine silk. The apex of the constructed plastic tube is attached to the anterior rectus sheath with chromic catgut to prevent retraction. About this, the abdominal wound is snugly closed. The plastic tube should protrude above the skin surface at least 0.5 cm., where it is fixed with interrupted fine silk sutures. The protruding catheter is surrounded with petrolatum gauze and extended through the entire dressing to facilitate feeding. The catheter should be left in place until the wound is firmly healed, when it may be removed

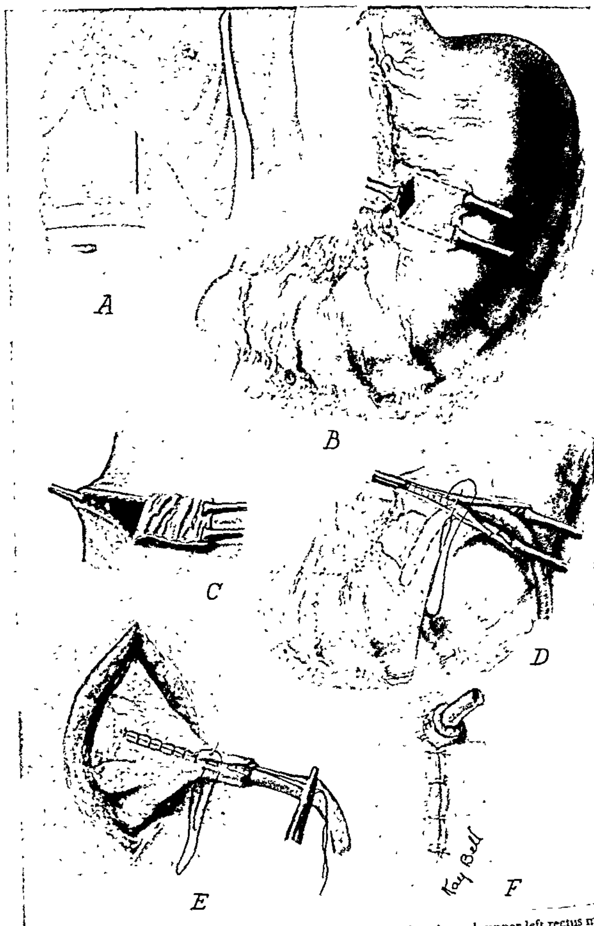


FIGURE 386. Technique of the Janeway gastrostomy A, Incision through upper left rectus muscle. B, Stomach wall flap outlined C, Stomach wall flap cut. It is usually advisable to make the stomach flap somewhat longer than is shown in these illustrations. D, Mucosa of stomach wall and flap sutured with chromic catgut E, Closure of stomach wound and stomach wall flap over a catheter. F, Abdominal wound closed, showing protruding tube of gastric wall containing catheter.

and introduced at feeding time. The mucosa-lined plastic tube makes a permanent fistula if retraction below the skin surface is prevented.

GASTROENTEROSTOMY

Dangers and Safeguards

Gastroenterostomy alone is seldom used for the treatment of duodenal ulcer today. Patients having obstructing ulcers who are extremely poor operative risks because of age or intercurrent disease may best be treated by simple gastroenterostomy. In addition, this procedure may be used for nonresectable carcinoma with obstruction. Gastroenterostomy has its widest application when used in conjunction with vagotomy.

Leakage at the site of the anastomosis is avoided by the careful approximation of the walls of the stomach and jejunum about the opening with two rows of sutures. Silk sutures may be used in the serosa, but should not be used in the mucosa. Some have believed that silk used in the mucosa predisposes to ulcer formation. Postoperative hemorrhage may occur if sutures are not placed during the operation so that all bleeding is completely controlled. A running lock-stitch or a cobbler's type of suture for the inside or mucosal suture line will adequately control bleeding. Needle puncture of veins near the greater curvature will cause local bleeding and the formation of hematomas which may retard healing.

When making an opening through the transverse mesocolon for a posterior gastroenterostomy, injury to the middle colic artery must be avoided. Section of this artery would necessitate resection of a portion of the transverse colon. To the left of the artery, a bloodless area is usually found which has been called the "space of Riolan." If the mesocolon is short or contains much fat, an anterior gastroenterostomy may be the procedure of choice.

Best results are obtained by making the anastomosis on the posterior wall of the stomach near the greater curvature side near the pyloric end of the stomach. As emphasized by Dragstedt, the stoma need be no longer than 4 to 5 cm. and must be placed near the pyloric end of the stomach to avoid the accumulation of gastric contents in the gastric antrum.

When doing a palliative gastroenterostomy for obstruction of the pylorus, due to cancer, the stoma should be placed at some distance from the tumor to avoid encroachment of the growth and secondary obstruction. Whether the stoma is placed parallel, oblique or vertical to the lesser curvature seems to make little difference in its function if kinking of the jejunum is avoided. It does not matter whether the anastomosis is made in the isoperistaltic or antiperistaltic manner as long as the position of the jejunal loop is unaltered and there is no kinking following completion of the anastomosis.

The margins of the opening in the mesocolon should be carefully sutured to the stomach wall about the anastomosis to prevent herniation, constriction or kinking of the bowel. The isoperistaltic or antiperistaltic type of anastomosis is satisfactory if angulation of the jejunum is avoided. A loop at least 8 to 10 cm. long will be found an advantage if it subsequently becomes necessary to detach the anastomosis as a result

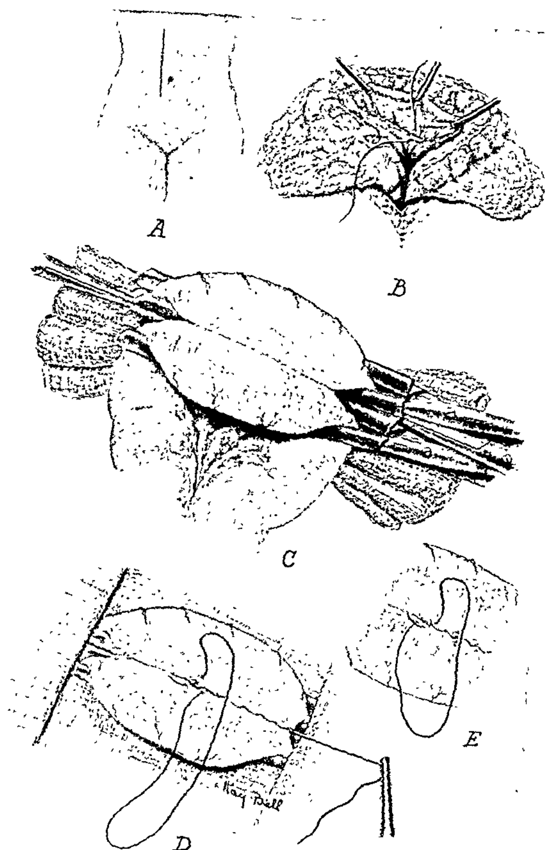


FIGURE 387. *Technique of posterior gastroenterostomy. A, A right (or left) paramedian incision may be used B, Posterior wall of stomach drawn through an opening made in the mesocolon. The mesocolon is being sutured to the posterior wall of the stomach. C, Rubber-shod clamps applied to stomach and jejunum D, Continuous seromuscular suture uniting the stomach and jejunum E, Showing detail of "switch-back" stitch to add security to suture line* (Orr: Surg, Gynec. & Obst)

of the formation of a gastrojejunal ulcer. The use of clamps to control bleeding has been censured by some surgeons, but it is doubtful whether they are harmful if properly used. The ease, neatness and rapidity with which the operation can be done when bleeding is controlled by rubber-shod clamps outweigh the possible danger of their use.

Technique of Posterior Gastroenterostomy (Figs. 387 to 390)

An incision is made just to the right or left of the midline about 12 to 14 cm. long with the umbilicus at the junction of the lower and middle thirds. A general exploration of the abdomen is made. The stomach is inspected and carefully palpated to identify all pathologic involvements. The transverse colon with its attached omentum is lifted into the wound and the mesocolon with its vessels identified. A short incision is made in the mesocolon opposite the dependent portion of the stomach through a relatively avascular area, preferably to the left of the middle colic artery. The opening is enlarged so that at least 8 to 10 cm. of the posterior stomach wall may be drawn through the opening. Allis clamps may be used on the stomach wall to mark the line of incision and to aid in the application of the hemostatic clamps. At this point the

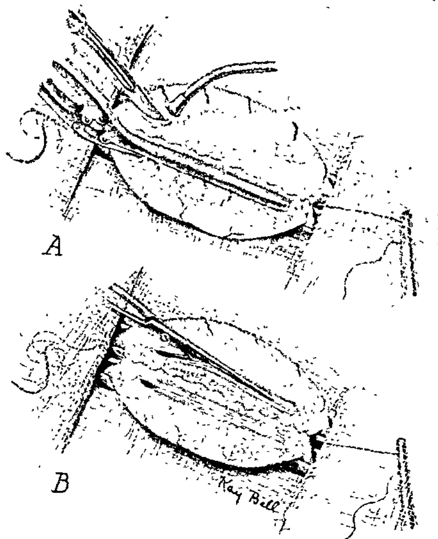


FIGURE 388. Technique of posterior gastroenterostomy (*continued*). *A*, Stab wounds are made in the walls of the stomach and duodenum for insertion of Payr crushing clamps. *B*, Incisions in stomach and duodenum are made along crushed tracts. (Orr: Surg., Gynec. & Obst.)

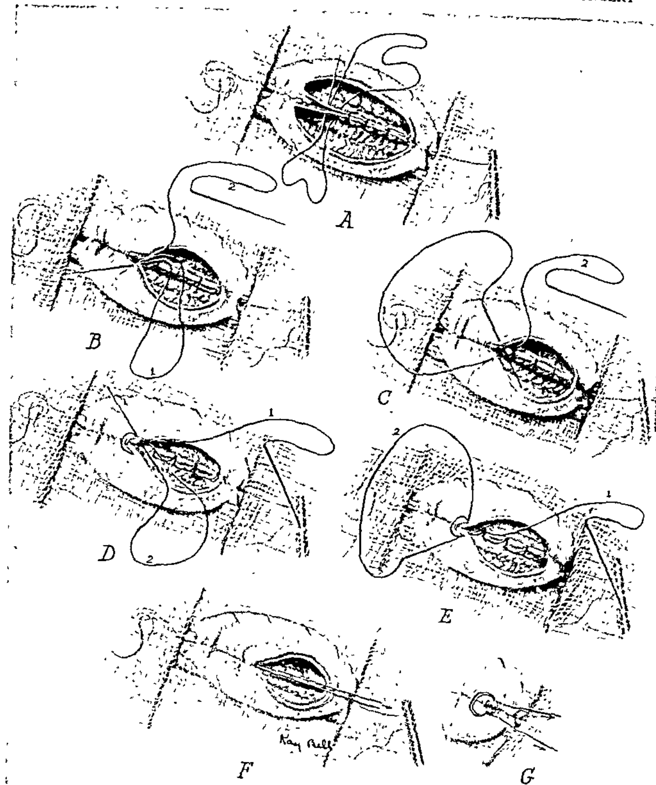


FIGURE 389 Technique of posterior gastroenterostomy (*continued*) *A*, Posterior inner row of sutures being placed as a shoemaker's stitch Every second suture is tied. *B*, *C*, *D*, *E*, Details of the placing of anterior inner row of double Connell sutures. Every second suture is tied inside to add security to the suture line. *F*, Detail of final sutures to close securely the end of the incision. All sutures are hemostatic and approximate serosa to serosa (Orr. Surg., Gynec. & Obst.)

mesocolon is sutured to the stomach wall posterior to the site of the proposed anastomosis. The first portion of the jejunum is identified by locating the ligament of Treitz. It is lifted into the wound and the site of anastomosis located and marked by Allis clamps leaving a loop 8 to 10 cm. long. If the Treitz ligament produces any angulation, it should be severed. Hemostatic rubber-shod clamps are applied to the stomach

and jejunum, and the Allis forceps are removed. After placing a strip of gauze beneath the clamps between the stomach and jejunum, the two clamps are fixed together by hemostats caught in the rubber tubing on the medial blades. The operative field and exposed intestine and omentum are protected by four moist gauze packs.

The first line of fine silk sutures is placed as interrupted Lembert sutures or as a continuous Lembert suture with a "switch-back" stitch placed every third stitch for fixation. After completing the posterior suture line, the free end of the suture and the end carrying the needle are placed beneath the gauze packs for future use. An incision 5 cm. long is made in the gastric wall 0.5 cm. from the suture line. A similar incision is made in the jejunum. The technique is somewhat simplified by crushing the walls of the stomach and jejunum along the line of incision with Payr clamps. The anastomosis is made somewhat easier if the opening in the jejunum is slightly shorter than in the stomach, since the jejunal wall stretches more readily than the stomach wall.

The opened stomach and jejunum are carefully cleansed with gauze sponges or by suction. The inner posterior row of sutures which pass through the entire thickness

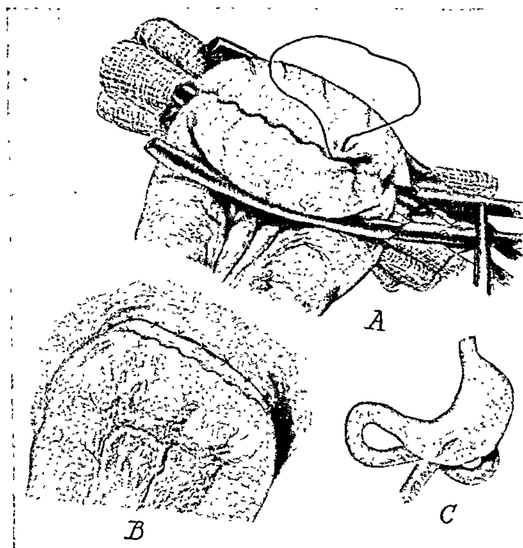


FIGURE 390 Technique of posterior gastroenterostomy (*concluded*). *A*, The hemostatic rubber-shod clamps are loosened, and the anterior seromuscular continuous sutures are being placed. *B*, Anastomosis complete. Margin of opening in mesocolon is sutured to stomach wall *C*, Diagram of completed operation. (Orr: Surg , Gynec. & Obst.)

of the stomach and jejunal walls may be placed as a continuous lock-stitch or cobbler's stitch, using no. 000 chromic catgut. The anterior wound margins may be closed with a lockstitch or a Connell suture. A suture fitted with an atraumatic needle at each end is an advantage in placing the Connell stitches. The anterior serosal row of sutures should be silk and may be placed as continuous or interrupted Lembert sutures. The anterior and posterior serosal sutures extend at least 1 cm. beyond the gastrojejunal stoma at each end to obtain firm approximation and avoid leakage. The anterior opening in the mesocolon is sutured to the stomach wall about 1 cm. from the anastomotic line.

Technique of Anterior Gastroenterostomy (Figs. 391, 392)

For certain technical reasons such as adhesions, short or fat mesocolon, or deformity of the stomach due to neoplasm, an anterior gastroenterostomy may be indicated.

A loop of jejunum, sufficiently long to prevent kinking and pressure on the lumen by the movable transverse colon, is brought anterior to the colon and anastomosed to the stomach at its most dependent part and as near the greater curvature as possible. The steps in the technique of anastomosis are the same as those used in posterior gastroenterostomy. Some surgeons prefer an added jejunojejunostomy to avoid stasis in the proximal gut, but this step is probably unnecessary if the loop of jejunum is sufficiently long to prevent any angulation or pressure on its lumen. A jejunojejunostomy

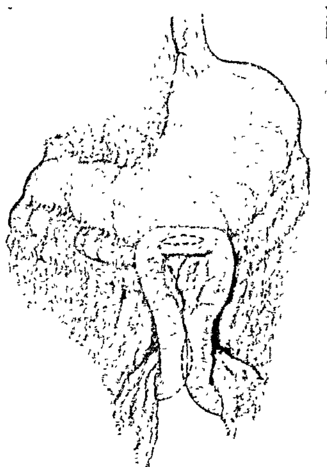


FIGURE 391. Anterior gastroenterostomy with enteroenterostomy.

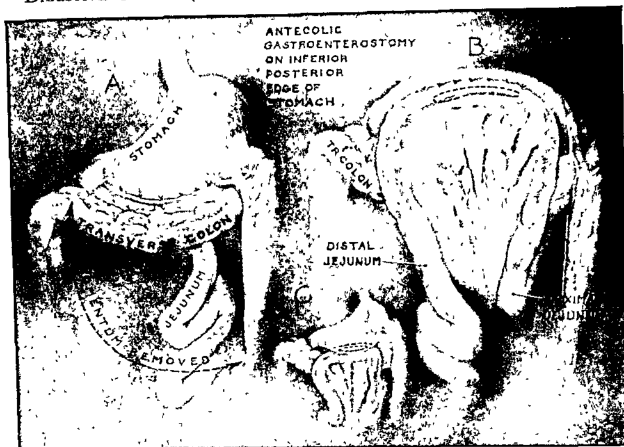


FIGURE 392. Lahey technique of antecolic gastroenterostomy. The omentum is removed over to the left side of the greater curvature. The greater curvature of the stomach is completely freed, and the gastrojejunostomy is made just behind the greater curvature edge. (Redrawn from Lahey: Surg., Gynec. & Obst., Vol. 78.)

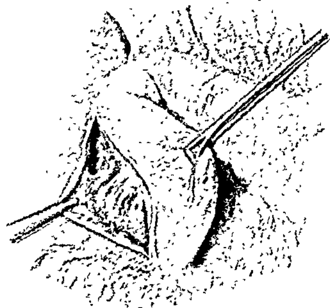
is contraindicated when there is hyperacidity. The alkaline contents of the upper bowel are needed to neutralize the acid gastric juice.

Lahey recommends a technique for anterior gastroenterostomy in which a large portion of the great omentum is removed. The greater curvature of the stomach is completely freed, and the jejunum is anastomosed just behind the greater curvature margin. The stoma may be made as large as desired without fear of torsion or angulation of the jejunum. Removal of the omentum prevents impingement of this structure upon the jejunal loop.

GASTRODUODENOSTOMY

General Considerations

The indications for this operation differ little from those for pyloroplasty. In some instances gastroduodenostomy may be the simpler operation, especially when scarring and adhesions are present in or about the pylorus. The physiologic basis for this operation is clear. Gastric contents entering the duodenum near the site of its normal entrance minimize the danger of recurrent ulcer. A generous opening permits a ready intermingling of the duodenal and gastric secretions. Clute and Sprague emphasize the relative infrequency of suture line ulcers following this operation as compared with marginal ulcers complicating gastroenterostomy.



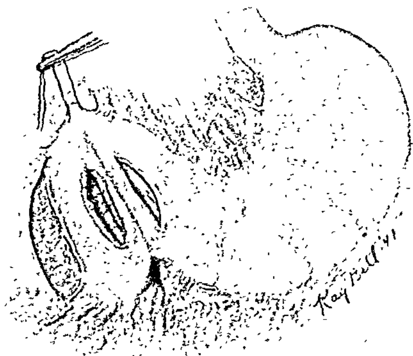


FIGURE 393 Technique of gastroduodenostomy *A*, Mobilization of duodenum after dividing its peritoneal reflection. *B*, The duodenum and antrum of the stomach have been united with a row of sutures. Incisions into duodenum and stomach preparatory to completing anastomosis.

Technique of Operation (Fig. 393)

A right paramedian incision gives good exposure. The operative field is carefully protected by moist gauze packs. The first, second and occasionally a portion of the third division of the duodenum are mobilized by cutting the parietal peritoneum at its reflection from the duodenal wall. This area is relatively avascular. By blunt dissection accompanied by a lifting and rolling motion of the duodenum, it is easily freed until it can be approximated to the antrum of the stomach without tension. Careful dissection will avoid damage to the pancreas and its blood supply. The duodenum must not be rotated or twisted when sutured to the stomach.

A traction suture is placed in the anterior wall of the pylorus, and the duodenal and stomach walls are grasped with Allis forceps. The first row of sutures is placed approximating the duodenum and stomach for a distance of at least 7.5 cm. Fine silk is satisfactory, placed as interrupted sutures or as a continuous suture with an occasional "switch-back" stitch for fixation. The anastomotic opening should not be less than 6 cm. long. The duodenum and stomach are carefully opened about 0.5 cm. from the suture line, using suction to prevent soiling. Small vessels are clamped and tied with fine catgut. Number 00 chromic catgut is used for the second row of sutures placed as a lock-stitch or cobbler's type of stitch to prevent bleeding. This is continued anteriorly as a Connell suture. The anterior row of seromuscular sutures is completed with silk placed as interrupted or continuous Lembert sutures. A small portion of the omentum is stitched over the suture line for added protection and to lessen adhesions. The abdominal wound is closed without drainage.

PYLOROPLASTY

General Considerations

Pyloroplasty is an operation designed to cut the pyloric ring and enlarge the opening between the stomach and duodenum. This relieves pyloric spasm and permits rapid emptying of the stomach as well as a free intermingling of the alkaline duodenal and acid gastric secretions. The operation is indicated in selected cases of duodenal ulcer or pylorospasm when there is little organic cicatricial contraction of the pyloric ring or in conjunction with vagotomy. If conveniently located, a duodenal ulcer may be excised as a step in the pyloroplastic operation. If there is organic obstruction at the pylorus, gastroenterostomy is usually the operation of choice.

Dangers and Safeguards

Pyloroplasty has a low mortality rate. The danger of bleeding or postoperative infection is slight. To avoid tension on suture lines, the first and second portions of the duodenum should be mobilized so that the duodenal and gastric walls are readily approximated. Excision of an ulcer may distort the suture lines, making closure more difficult. Injury to the common bile duct and pancreas must be avoided. Careful approximation with a double row of sutures will prevent postoperative leakage. A postoperative leak will result fatally in a large percentage of cases. The preoperative preparation and postoperative care do not differ from the treatment of gastroenterostomy.

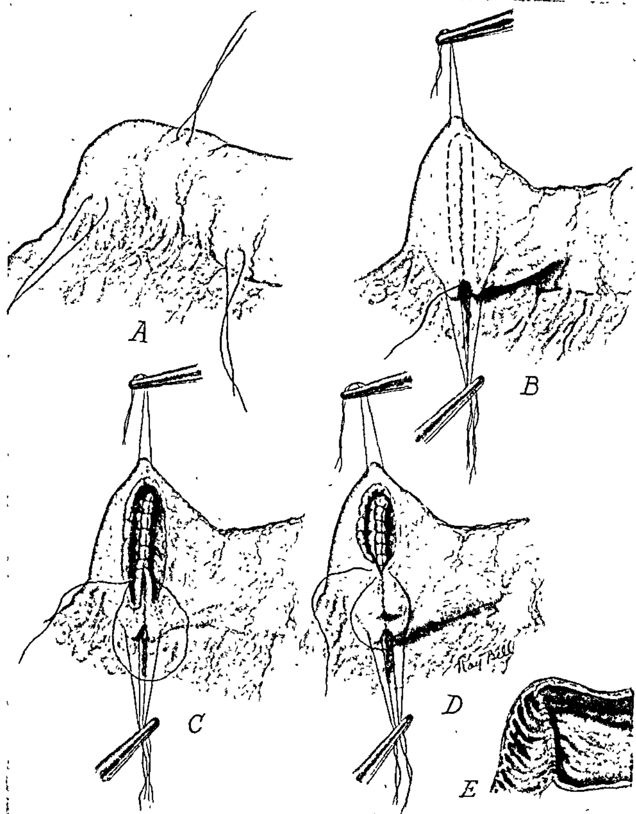


FIGURE 394 Technique of the Finney pyloroplasty. *A*, Traction sutures placed in stomach and duodenum *B*, Stomach and duodenum sutured together. Line of incision in stomach and duodenum *C*, Stomach and duodenum opened and posterior row of through-and-through sutures being placed. *D*, Anterior row of Connell sutures being placed. *E*, Cross section of pyloroplastic stoma

Technique of Finney Pyloroplasty (Fig. 394)

A right paramedian incision is made. The pylorus and first and second portions of the duodenum are mobilized by cutting the peritoneal reflection along the right margin. This area is relatively avascular. Traction sutures are placed at the pyloric

ring and in the walls of the stomach and duodenum marking the extent of the incisions. The incisions in the stomach and duodenum should each be approximately 7.5 cm. long.

Traction downward on the marker sutures in the duodenum and stomach will bring the stomach and duodenum into close approximation. The first row of sutures is placed from the pylorus downward to a point 1 cm. beyond the proposed incision to permit secure closure at this point. This row of sutures may be placed as a continuous suture or as interrupted sutures of silk. An incision is then made through the wall of the duodenum, pyloric ring and stomach wall about 0.5 cm. from the suture line. Secretions and blood from the duodenum and stomach should be removed by sponging or, preferably, by suction. An ulcer near the line of incision in the duodenum or stomach may be completely excised. The second or internal row of lock-stitch sutures is placed, beginning at the pylorus. At the lower end of the incision the suture is tied and the free end continued as the anterior portion of the internal row ending at the pylorus. If a continuous serosal suture is used, the free end of the first suture is picked up and continued upward to the pylorus as the anterior external suture. A small portion of gastrocolic omentum stitched to the suture line adds security and minimizes adhesions. The abdominal wound is closed without drainage.

Technique of Heineke-Mikulicz Pyloroplasty (Fig. 395)

When the pyloric region has been exposed, traction sutures of silk are placed a few millimeters apart on the anterior surface of the pylorus. A longitudinal incision

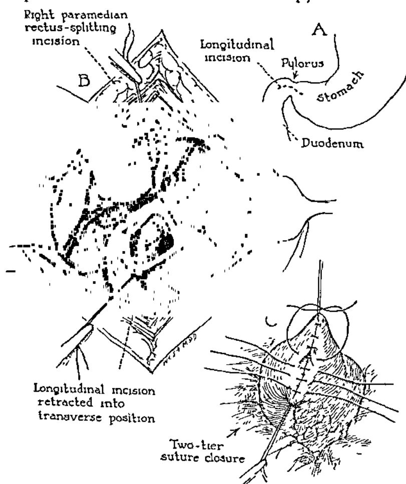


FIGURE 395. Technique of Heineke-Mikulicz pyloroplasty. *A*, Longitudinal incision across the pylorus *B*, Conversion of longitudinal incision into a transverse incision, using traction sutures. *C*, Closure with 2 layers of sutures. (Shackelford: Surgery of the Alimentary Tract, Vol. I.)

is then made between the two traction sutures, extending about 2 cm. in each direction from the pylorus. By placing traction on the sutures, the incision is converted into one running transversely. This transverse incision is then closed as illustrated, using two layers of interrupted silk sutures. A continuous suture tends to diminish the lumen by its purse-string effect. By placing the inner layer of sutures so that the knots are tied on the inside, inversion of the mucosa layer can be obtained. This technique enlarges the lumen of the pyloric canal in an effective and simple manner.

EXCISION OF GASTRIC ULCER

General Considerations

Certain types of gastric ulcer may be successfully excised. This is particularly true of small ulcers so situated that technical difficulties may not be too great. When an ulcer is excised, the excision should usually be followed by posterior gastroenterostomy. If the ulcer is large, perforating or possibly malignant, subtotal gastrectomy is the operation of choice. Excision of a gastric ulcer with gastroenterostomy usually has a lower mortality rate than gastric resection. Careful medical treatment should follow such operations.

Technique of Wedge Excision (Figs. 396, 397)

After separating the gastrohepatic omentum and inflammatory adhesions from the lesser curvature of the stomach, the gastric wall about the ulcer is fixed with Allis clamps. An opening through the gastric wall is made large enough to admit the finger. The size and exact location of the ulcer are determined by palpation. Soiling is

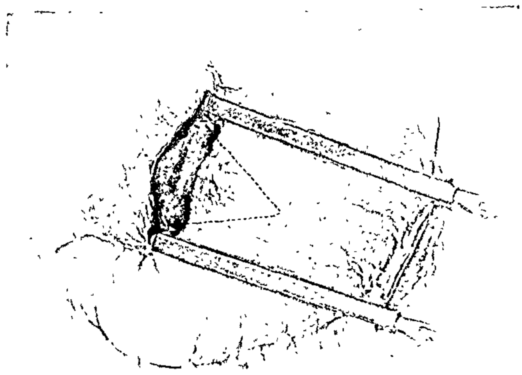


FIGURE 396 Wedge resection of gastric ulcer. (Walton. Nelson's Loose-Leaf Surgery, Vol. V.)

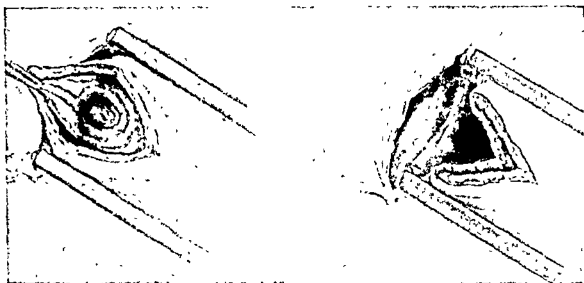


FIGURE 397. Wedge resection of gastric ulcer (*continued*). *Left*, The anterior wedge of the lesser curvature is excised first so that the limits of the ulcer can be seen. *Right*, Wedge of stomach excised with the ulcer-bearing area. (Walton: Nelson's Loose-Leaf Surgery, Vol. V.)

prevented by suction cleansing. The incision is extended around the ulcer crater across the lesser curvature, cutting a wedge-shaped portion from the anterior and posterior stomach walls. The wound is closed with a row of through-and-through no. 00 chromic catgut sutures to control bleeding. Over this is placed a row of interrupted fine silk sutures. The gastrohepatic omentum is sutured to the lesser gastric curvature. Drainage is not necessary unless there has been definite soiling.

PERFORATED GASTRIC OR DUODENAL ULCER

General Considerations

Ulcer of the duodenum perforates more frequently than gastric ulcer. Most of such ulcers perforate through the anterior wall. Ulcers perforating through the posterior wall of the duodenum or stomach are more frequently walled off by adhesions than those perforating through the anterior wall. Posterior wall perforations present greater operative difficulties than anterior.

Dangers and Safeguards

Early recognition of the condition and prompt treatment are essential if a low mortality rate is to be expected. When a perforation is suspected, the stomach should be promptly emptied by gastric suction. Suction should be maintained until operation and for three or four days following operation. Gastric lavage is contraindicated. A minimum operative procedure to control leakage from the ulcer is the treatment of choice. Excision of the ulcer, gastroenterostomy or subtotal gastrectomy adds to the operative mortality rate and should be postponed until a later date. Unless there is present an accumulation of purulent material in the peritoneal cavity, drainage is of doubtful value. In many instances cultures of the exudate are sterile; however, antimicrobials should be used. In the late cases most surgeons drain the right subhepatic space and occasionally the right pelvis through a stab wound.

Postoperative continuous gastric suction and the administration of intravenous and subcutaneous solutions of 5 per cent dextrose and physiologic sodium chloride solutions are essential. If the hemoglobin is reduced, transfusions are indicated.

In general, the mortality rate increases in direct proportion to the time elapsing between acute perforation and the operative treatment. The age of the patient, quantity of material which leaks into the peritoneal cavity, and the types of microorganisms present also have a direct bearing upon mortality.

Technique of Closure of Perforated Ulcer (Graham) (Fig. 398)

Spinal anesthesia is recommended by Graham to minimize dissemination of duodenal contents by reducing respiratory effort and diaphragmatic movements. A carefully administered inhalation anesthetic is satisfactory. The actual operation consists in careful removal of all exudate from the peritoneal cavity with suction and sponging and simple closure of the perforation.

Three interrupted chromic catgut sutures are placed; one at the top, one in the middle and one at the bottom of the perforation. A piece of omentum, either free or attached, is laid over the sutures, which are then tied sufficiently tight to hold the omental graft snugly in place over the perforation. In most cases the edematous margins will tear easily if the sutures are tied with much tension. No effort is made to



FIGURE 398. Technique of closure of perforated duodenal ulcer. Three sutures placed, but not tied Insert shows sutures tied over a portion of omentum. No attempt is made to close the perforation with the sutures (Redrawn from R R Graham: Surg., Gynec. & Obst.)

close the perforation with the sutures, and only enough tension is applied to fix the graft firmly over the opening. The placing of several rows to turn the margins of the ulcer inward adds to the danger of obstruction of the duodenum and is not necessary to prevent leakage.

PARTIAL GASTRECTOMY

General Considerations

All partial resections of the stomach are based upon the original operations of Billroth, which are now known as Billroth I and Billroth II. Many modifications of these two operations have been described in surgical literature, only a few of which are in general use. After resecting a portion of the stomach, a union between the fundus portion and the duodenum appears to be the operation of choice from the physiological viewpoint. However, this type of operation (Billroth I) is not always possible because of mechanical difficulties. Anastomosis between the proximal portion of the stomach and the first part of the jejunum (Billroth II type) has given good clinical results when a large section of the stomach is removed. The type of operation now in general use is the Polya or Hofmeister.

In general, the *indications* for partial gastrectomy are duodenal ulcer which, because of bleeding, pyloric obstruction or intractability, cannot be managed medically; gastric ulcer; benign tumors of the stomach; and carcinoma involving the distal portion of the stomach.

There has not been complete agreement concerning the *extent* of partial gastrectomy for gastric and duodenal ulcers. Certainly a smaller resection can be done for gastric ulcer than for duodenal ulcer. Wangensteen advocated removal of 75 per cent of the stomach. Rienhoff described a technique for removal of approximately 50 per cent of the stomach. Graham resects three fifths of the stomach with the entire lesser curvature. Allen and Welch state that, based on their own observations and those of others, they have assumed that the operation should include removal of the distal two thirds of the stomach and the ulcer-bearing segment of the duodenum. Lahey is convinced that, when it can safely be done, a high subtotal gastrectomy with removal of three fourths to four fifths of the stomach, with the duodenal ulcer, is the best surgical method of treating duodenal ulcer. Recently the use of vagotomy combined with gastroenterostomy or with 50 per cent gastrectomy has been advocated. These procedures have certain theoretical advantages, but have not been evaluated sufficiently to replace partial gastrectomy as the operation of choice for routine use.

There is a difference of opinion concerning the *type of gastrojejunostomy* that should be done after a partial gastrectomy for peptic ulcer. Wangensteen believes that a long duodenojejunal loop invites stomal ulcer and recommends a postcolic anastomosis with a short loop. His opinion is based upon both experimental and clinical evidence. Allen and Welch recommend a postcolic Hofmeister type of gastrojejunal anastomosis as close to the ligament of Treitz as possible. Rienhoff uses the antecolic Polya-Balfour type of gastrojejunostomy. Schmidt and Melick state that their results offer corroborative evidence to substantiate the established fact that the long loop antecolic method of gastrojejunal anastomosis is a satisfactory procedure.

Partial gastrectomy for cancer should include a wide margin of stomach beyond the tumor, resection of the gastrohepatic and gastrocolic ligaments, and the great omentum. Splenectomy is indicated if the tumor has spread to the region of the splenic pedicle. Partial gastrectomy for benign ulcers should be done with a minimum of resection of surrounding structures.

Dangers and Safeguards

Many patients having surgical lesions of the stomach are poor operative risks. The *preoperative study and preparation* of such patients is imperative to prevent a high surgical mortality rate. If the hemoglobin is low, transfusions should be given before operation, and blood should be available for transfusion during and immediately after operation. If there is obstruction at or near the pylorus, special attention should be given to the preparation of the stomach. There is likely to be infection, edema, and dilatation of the stomach wall. In such a condition continuous gastric suction and lavage are indicated, sometimes as long as three or four days before operation. This lavage and decompression reduce the infection and edema, permit return of gastric tone, and increase the blood supply, thus making operation upon the gastric wall technically easier and ensuring more rapid healing. During the period of preparation by gastric suction, liberal quantities of 5 per cent dextrose in physiologic sodium chloride solution should be given to aid in maintaining water and chemical balance. When gastric lesions are present, especially on the greater curvature, it may be advisable to prepare the colon with antimicrobials before operation so that portions of the colon can be resected safely if indicated.

After operation gastric retention is prevented by gastric suction until the stomach and jejunum have resumed function. This period is usually not longer than forty-eight hours. In a small percentage of cases return of function may be delayed several days. Jejunostomy may be necessary in such cases to permit feeding. Shock, hemorrhage and wound soiling increase the mortality rate. Technical errors in the placing of sutures permitting leakage may result in disaster. All suture lines should be watertight when the operation is finished.

The operative mortality rate of elective partial gastrectomies for ulcers of the stomach or duodenum should not exceed 2 to 3 per cent. Operations for bleeding ulcers have a higher mortality rate. Gastric resections for carcinoma of the stomach have a relatively high mortality rate, estimated at 15 to 25 per cent. The use of the antimicrobial drugs will reduce the hazard of these operations.

Technique of Billroth I (Fig. 399)

An incision may be made to the right or left near the midline, depending upon the location of the lesion, extending from near the ensiform to or below the level of the umbilicus, or a transverse incision may be preferred, especially in patients having a wide costal arch. In all gastric operations a careful inspection and palpation should be made of the entire stomach, duodenum and nearby organs before planning the steps of the procedure.

An opening is made in the gastrohepatic omentum large enough to admit two fingers. The fingers are then inserted behind the stomach to the greater curvature to separate the gastrocolic omentum from the colon mesentery. This step is important to

avoid injury to the middle colic artery. Severance of the middle colic artery will result in gangrene of a section of the transverse colon. The vessels in the gastrocolic omentum are clamped, cut, and ligated to a point on the greater curvature 2 cm. beyond the point selected to resect the stomach. The right and left gastroepiploic arteries and veins are severed and ligated. These ligations free the greater curvature. In like manner the vessels in the gastrohepatic omentum are severed and ligated, freeing the stomach portion to be removed. Adhesions on the stomach surface should be divided.

The first portion of the duodenum is dissected free, and all bleeding points are carefully controlled. Small Payr clamps are applied, one on the first portion of the duodenum just distal to the pylorus and the other at the pylorus. As much of the duodenum as possible is preserved. After placing protective moist gauze pads behind the stomach, the duodenum is severed between the clamps, cutting away all tissue down to the duodenal clamp. The stomach is then lifted and used as a tractor while large Payr clamps are applied at the site of resection and the stomach is severed.

The lesser curvature side of the amputated stomach is then closed, leaving a portion on the greater curvature side the same diameter as the amputated duodenum. The closure is done with two layers of continuous chromic catgut and a third layer of silk for inversion and reinforcement.

The clamps on the duodenum and stomach are approximated, and interrupted Lembert sutures of fine silk are used to unite the seromuscular coats of the stomach and duodenum, beginning at the greater curvature of the stomach. After placing a rubber-shod hemostatic clamp on the stomach proximal to the Payr clamp, both Payr clamps are removed. Soiling is prevented by suction cleansing. The next suture is

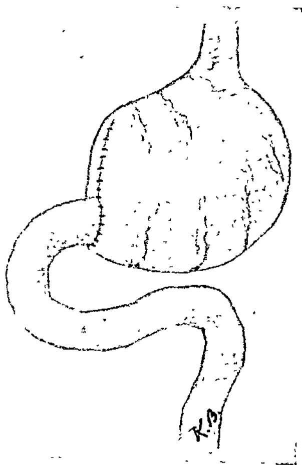


FIGURE 399 Method of uniting duodenum to stomach in the Billroth I technique of partial gastrectomy

placed through-and-through both gastric and duodenal walls as interrupted or lock-stitch sutures of fine chromic catgut. An anterior row of interrupted Lembert stitches of silk completes the anastomosis. Additional reinforcing sutures should be placed at the angles. Care must be taken at the corner where the lesser curvature side of the duodenum is sutured to the closed portion of the stomach, since this represents the weakest point of the anastomosis.

The gastrohepatic and gastrocolic omenta are sutured to the stomach, and a portion of the great omentum is stitched along the suture line.

Drainage is not necessary unless there has been soiling or unless a perforating ulcer has complicated the operation. If a perforating ulcer is attached to the pancreas, the stomach should be emptied completely by aspiration through a stab wound before releasing the ulcer.

Technique of Finney-Haberer Modification of Billroth I (Fig. 400)

This type of anastomosis is particularly valuable to re-establish intestinal continuity when a previously constructed gastroenterostomy following gastric resection must be disconnected because of marginal ulcer or nutritional difficulties.

The duodenum is fully mobilized as described for pyloroplasty. The section of the stomach to be removed is resected as described above under the Billroth I technique.

The duodenum is closed with no. 00 chromic catgut placed as a continuous suture over the Payr clamp and drawn tight as the clamp is removed. This turns the cut end of the duodenum in, approximating the serosal surfaces. The suture is turned back, and a row of continuous Lembert sutures reinforces the first row. The ends of the suture are tied together. It is well to reinforce these two suture lines with Lembert or Halsted sutures of fine silk. Two or three sutures of silk may later be utilized at the

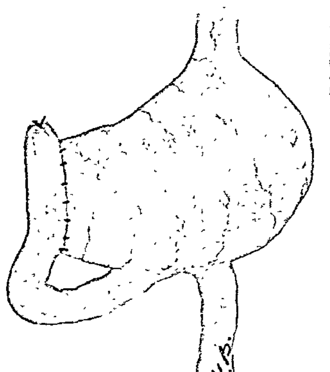


FIGURE 400. Finney-Haberer partial gastrectomy. The end of the duodenum is closed, the duodenum is mobilized, and an anastomosis is made between the duodenum and sectioned end of the stomach Technique of anastomosis same as that for gastroenterostomy.

completion of the operation for the attachment of a small portion of omentum to afford protection to the duodenal suture line.

The severed end of the stomach is placed in contact with the duodenal wall and an anastomosis made as in gastroenterostomy. The first seromuscular row of sutures is placed before removing the Payr clamp from the stomach. A rubber-shod clamp is placed on the stomach, and the Payr clamp is removed. The anastomosis is covered with omentum. The lesser curvature side of the amputated stomach may be closed and only a portion of the width on the greater curvature side used for the anastomosis as in the Hofmeister procedure if preferred.

Technique of Billroth II (Fig. 401)

This operation, introduced shortly after the Billroth I operation, previously described, is rarely used today and is presented chiefly for historical interest. The Hofmeister and Polya operations, however, are only modifications of the Billroth II procedure.

The stomach is freed from its blood vessel and omental attachments as in the Billroth I. The duodenum is severed with a cautery at the pylorus between small Payr clamps and closed. The site of resection of the stomach is clamped with two large Payr clamps and divided between the clamps with a cautery. The proximal segment of the stomach is closed with a row of through-and-through sutures of no. 00 chromic catgut placed against the clamp. This suture line closes the stomach so that the clamp may be removed without soiling. This suture is turned back and placed as a second row of Lembert sutures with a "switch-back" stitch at every third suture. This second row of sutures is further reinforced with a row of interrupted sutures of fine silk.

A typical posterior gastroenterostomy is done by the technique described elsewhere. If sufficient exposure of the posterior gastric wall cannot be obtained for a posterior gastroenterostomy, an anterior gastroenterostomy may be done.

Technique of Polya (Figs. 402, 403)

This is one of the most practical methods of resection of the stomach, particularly when a large portion is to be removed.

The field of operation is carefully explored first. If a resection for carcinoma is contemplated, it is imperative that the stomach and adjacent structures be carefully examined to determine operability before dissection is begun. An opening is made in the gastrohepatic omentum for the insertion of one or two fingers. Through this opening the posterior surface of the stomach is explored and the gastrocolic omentum identified to avoid injury to the middle colic artery. A tape is passed around the midportion of the stomach for traction.

The dissection is usually begun at the pylorus. If there are many adhesions about the pyloric area, the body of the stomach may be freed first. The vessels along the greater and lesser curvatures are divided between clamps and ligated. If the resection is for carcinoma, as much as possible of the gastrocolic and gastrohepatic ligaments is removed. If extensive resection is necessary, or if there is any doubt about the spread of the tumor, the great omentum and spleen should be removed with the stomach. At the site of the resection the gastric artery and veins on the lesser curvature and the gastroepiploic vessels on the greater curvature are ligated and severed about 2.5 cm.

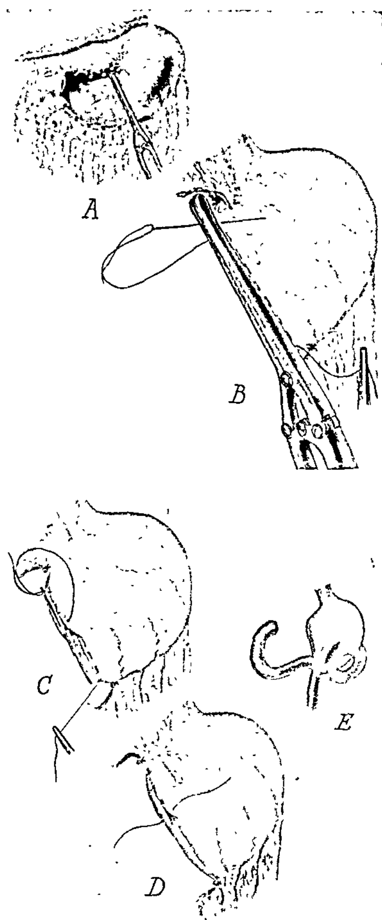


FIGURE 401 Technique of Billroth II partial gastrectomy. *A*, Payr clamp in place after resection of a portion of the stomach *B*, A through-and-through continuous suture is placed to prevent leakage when the clamp is removed. *C*, Seromuscular inverting suture. *D*, Third row of interrupted Lembert sutures. *E*, Posterior gastroenterostomy.



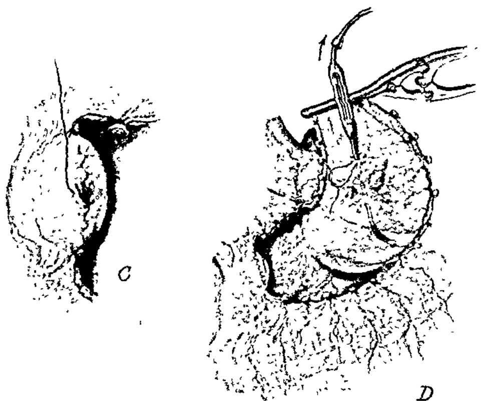


FIGURE 402 Technique of partial gastrectomy by the Polya method *A*, Duodenum has been divided between small Payr clamps A continuous Cushing suture of no. 00 chromic catgut is placed over the clamp. *B*, Cut end of duodenum is inverted as clamp is withdrawn. *C*, Second row of continuous Lembert sutures. This row of sutures should be reinforced with a third row of interrupted Lembert sutures of silk. *D*, Stomach mobilized by dividing and ligating the gastrohepatic and gastrocolic ligaments Gas and liquid may be aspirated through a stab wound in the stomach or by a tube passed through the nose into the stomach. (*See continuation of figure on next page*)

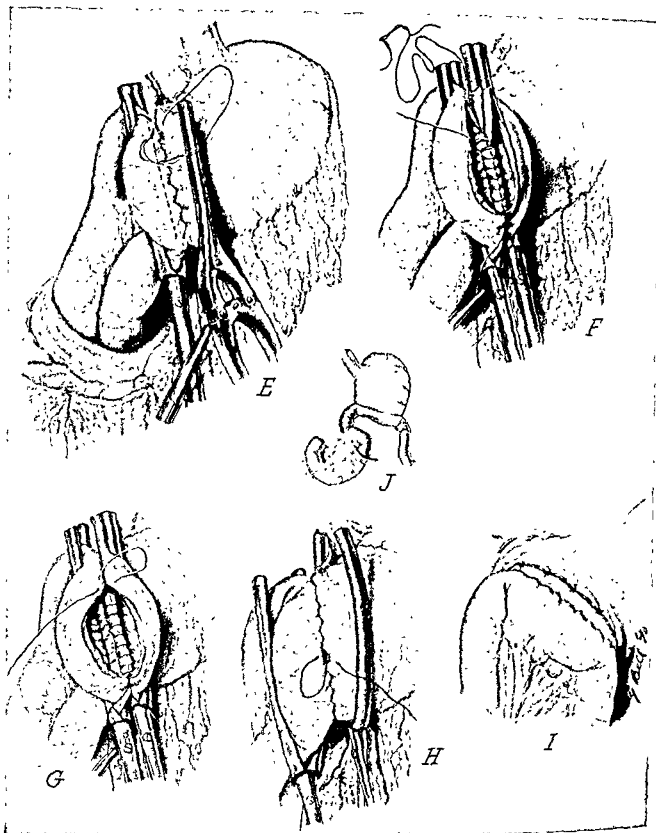


FIGURE 403 Technique of partial gastrectomy by the Polya method (*continued*). *E*, Stomach has been divided between Payr clamps. Jejunum is drawn through an opening made in the mesocolon and the first row of sutures placed *F*, Second or inside row of lock-stitch sutures. *G*, Anterior inside row of Connell sutures being placed *H*, Anterior outside row of continuous Lembert sutures *I*, Anastomosis completed with mesocolon sutured to stomach wall. *J*, Diagram of completed anastomosis.

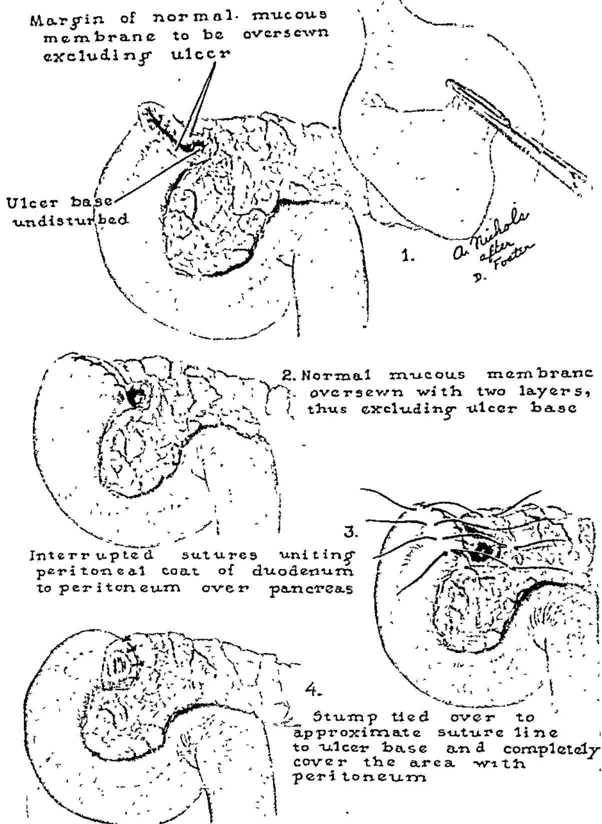


FIGURE 404. Technique of exteriorization of penetrating posterior wall duodenal ulcer. *1*, Penetrating ulcer left undisturbed after section of duodenum *2*, Open end of duodenum closed, leaving the ulcer outside the lumen of the duodenum *3*, Interrupted sutures uniting peritoneal coat of duodenum to peritoneum over pancreas. *4*, Closed duodenal stump in contact with ulcer base. (Redrawn from Graham, S Clin. North America.)

proximal to the line of resection. The first portion of the duodenum is freed for about 2.5 cm. After the stomach has been freed the duodenum is divided with a cautery or knife between small Payr or Ochsner clamps near the pyloric ring. The stomach is then retracted to the left, and the duodenum is closed with two rows of fine chromic catgut sutures, reinforced with a row of Lembert sutures of silk. If there is a perforating ulcer against the pancreas, making resection of the ulcer-bearing area of the duodenum too hazardous, the technique of duodenal closure used by Graham is recommended (Fig. 404). In event that closure of the duodenal stump is not feasible, a catheter may be sutured into the lumen, brought out of the abdomen through a stab wound, and attached to suction. After removal in eight to twelve days, spontaneous closure of the resultant fistula ensues, provided no obstruction exists distally. The end results of the use of this technique have been highly satisfactory.

If the stomach contains gas or liquid, it is advantageous to empty it by suction through a puncture wound or through an indwelling nasal tube. The collapsed stomach is clamped across with a large Payr clamp about 2.5 cm. distal to the points on the greater and lesser curvatures which have been freed of blood vessels. This leaves a clean margin which may be used for anastomosis.

An opening is then made in a bloodless area of the transverse mesocolon, and the posterior margin of the opening is sutured well up on the posterior wall of the stomach with interrupted silk sutures. A loop of jejunum 10 to 15 cm. long is brought through the opening in the mesocolon and clamped with a rubber-covered hemostatic clamp A posterior row of no. 000 silk sutures is placed to unite the seromuscular coats of the stomach and jejunum. Torsion or angulation of the jejunum is avoided. The jejunum is opened along its antimesenteric border, a distance to equal the length of the severed end of the stomach. Careful cleansing of the opened jejunum by suction and sponging is necessary to prevent wound soiling. The distal portion of the stomach is removed by dividing it between Payr clamps. Before removing the proximal Payr clamp, a rubber-covered clamp is placed on the stomach to control leakage. The second row of sutures includes the full thickness of the stomach and jejunum. A continuous lock-stitch of chromic gut is preferred. The suture is tied at the end of the incision and returned to close the anterior margins of the wounds in the stomach and jejunum. A lock-stitch or Connell suture may be used. Number 00 or 000 chromic catgut is suitable for the inner rows of sutures. Silk is used for the anterior row of seromuscular sutures After completing the anastomosis, the anterior margin of the wound in the mesocolon is sutured to the wall of the stomach well above the anastomosis. This places the anastomosis completely below the mesocolon and serves to prevent angulation of the jejunum at the greater or lesser curvature of the stomach.

The abdominal wound is closed without drainage.

Technique of Hofmeister (Fig. 405)

This method of re-establishing intestinal continuity following partial gastrectomy is widely used at present It differs from the Polya technique in that the lesser curvature portion of the open end of the stomach is closed and the remaining portion of the open end of the stomach on the greater curvature side used for the anastomosis with a loop of jejunum. The loop of jejunum may be brought up either in front of or behind the transverse colon. The retrocolic anastomosis is to be preferred, since it permits a short

loop with less chance of kinking than with the full-width anastomosis. In addition, the anastomotic stoma is smaller with a resultant decrease in incidence and severity of the postgastrectomy syndrome.

The steps in this operation are the same as in the Polya up to the point of amputation of the stomach. Two Oschner clamps having jaws approximately 7 cm. in length are placed across the stomach on the greater curvature side, and the stomach cut partway across between the two clamps. This portion of the stomach is to be used for the anastomosis. A Payr crushing clamp is then placed across the remaining portion of the stomach and angulated upward toward the gastric cardia.

A rubber-shod clamp is placed distal to the Payr clamp to prevent spillage, and the remaining portion of the stomach is amputated along the Payr clamp with a knife. The lesser portion of the stomach contained in the Payr clamp is then closed. Starting on the lesser curvature side of the stomach, a 00 chromic catgut suture swaged

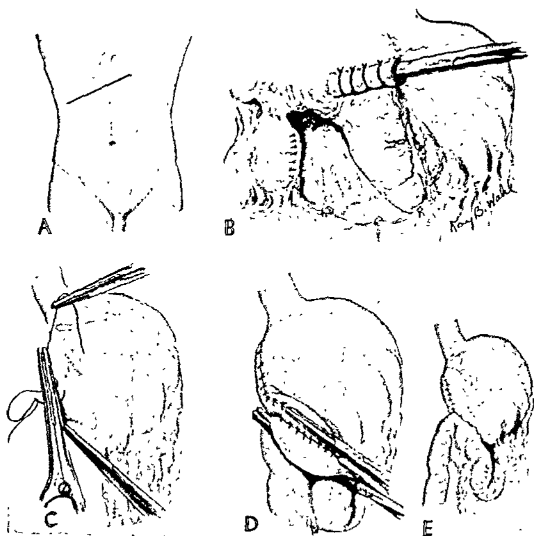


FIGURE 405. Hofmeister's method of partial gastrectomy. *A*, Transverse oblique incision suitable for upper abdominal operation in patients with wide costal arch. *B*, Mobilization of distal stomach, division of duodenum and closure of duodenal stump A short section of rubber tubing has been split and placed over the clamp on the pyloric end of the stomach to prevent soilage. *C*, After removal of the distal two thirds of the stomach the lesser curvature side is closed *D* and *E*, Intestinal continuity is re-established by an anastomosis between the greater curvature side of the stomach and jejunum.

on a curved atraumatic needle is placed back and forth beneath the Payr clamp to the point of the previously placed Oschner clamp. The Payr clamp is removed and a portion of the crushed end excised with scissors. The same suture is then used as a running inverting Lembert suture back to the point of origin on the lesser curvature and tied. The suture line is then reinforced with interrupted inverting Lembert sutures of silk or cotton.

An opening is then made in a bloodless area of the transverse mesocolon near the ligament of Treitz, and the posterior margin of the opening is sutured well up on the posterior wall of the stomach with interrupted silk sutures. A loop of jejunum is then brought up through the opening in the mesocolon. It may be advisable to divide the ligament of Treitz to make certain that no angulation occurs after completion of the anastomosis. A rubber-shod noncrushing clamp is then placed across the jejunal loop tangentially. A posterior row of 000 silk sutures is placed to unite the seromuscular coats of the stomach and jejunum.

The jejunum is then opened longitudinally, a distance equal to the portion of the stomach in the Oschner clamp. This opening should be approximately 2 to 3 mm. from the posterior row of sutures. A rubber-shod noncrushing gastrointestinal clamp is then placed across the stomach proximally and the Oschner clamp removed. The anastomosis is then completed with a continuous suture of 000 chromic catgut, as illustrated in Figures 382 and 405. Two separate sutures are used, starting at the midpoint of the posterior wall of the anastomosis and proceeding as a continuous lock suture in each direction to the angles, there to be tied with the knots inside the lumen This prevents a purse-stringing effect. Care must be taken at the area of the angle formed between the suture lines of the anastomosis and the partially closed end of the stomach. The same sutures are then used to approximate the anterior margin of the stoma as a continuous Connel suture to invert the mucosa and are tied at the midpoint anteriorly. The outer row of interrupted silk sutures is then completed anteriorly. Extra sutures between the jejunum and the stomach beyond the anastomosis are used to eliminate tension from the anastomosis line.

The anastomosis is then tested for patency and should be approximately 5 cm. in width. The anterior wall of the rent in the mesentery is sutured to the anterior wall of the stomach, thus bringing the entire anastomosis line below the transverse mesocolon. The abdomen is then closed without drainage.

Technique of the Devine Exclusion Operation

This operation may be indicated for inoperable carcinoma of the pyloric end of the stomach without obstruction. If this procedure is used for difficult duodenal ulcers, the antrum and pylorus must be resected at a later date. The extent of the tumor is determined and the stomach severed between two Payr clamps some distance from the growth to permit free closure of the distal end of the stomach. The anastomosis of the proximal portion of the stomach to the jejunum may be done by the Billroth II, Polya or Hofmeister technique as described above.

The lower segment of the stomach is closed with through-and-through chromic sutures near the clamp, a second row of seromuscular sutures and a reinforcing row of interrupted silk sutures.

VAGOTOMY

General Considerations

Interruption of the parasympathetic nervous stimuli to the stomach by division of both vagus nerves eliminates to a large degree the cephalic phase of gastric secretion. Because of gastric atony with resultant delay in emptying of the stomach, vagotomy alone is an unsatisfactory procedure and must be combined with some other procedure to prevent this undesirable effect of gastric retention. Vagotomy and gastroenterostomy, vagotomy and pyloroplasty and vagotomy combined with 50 per cent gastric resection are the procedures being used with moderate frequency today.

The most clear-cut indication for vagotomy is marginal ulcer which has developed after gastroenterostomy or gastric resection.

The exact place of vagotomy and gastroenterostomy and for 50 per cent gastrectomy combined with vagotomy in the management of duodenal ulcer is still controversial. None of the surgical procedures used for duodenal ulcer has proved completely satisfactory. It is therefore illogical to use any one type of operative procedure for all patients with duodenal ulcer who require operative intervention. Rather, an attempt should be made to select the operative procedure which best fits the patient under consideration. For example, the elderly patient with a chronic stenosing duodenal ulcer with obstruction or the patient with intercurrent disease may best be managed by vagotomy and gastroenterostomy. This procedure may also be indicated in the presence of a large ulcer with extensive scarring and edema or other factors making closure of the duodenal stump difficult and precarious. The thin, chronically underweight patient may best be treated by vagotomy-gastroenterostomy or vagotomy-50 per cent gastric resection.

Variations in the anatomy of the vagus nerve from what is considered normal are frequent. In every case of vagotomy a careful search should be made for all branches of the nerves both by visualization and palpation with the esophagus under tension. If nerve fibers to the stomach are not severed, the operation is incomplete, and doubtful results may be expected. Actual regeneration of the nerves following vagotomy is doubtful, provided all fibers have been removed and a segment of the nerves excised. However, patients who have had complete vagotomy as indicated by the Hollander insulin test after operation may subsequently show an increase in the output of hydrochloric acid following insulin hypoglycemia.

The vagus nerves may be approached either by the subdiaphragmatic route or transthoracically. This latter approach permits easier and better exposure of the nerves; however, it does not permit abdominal examination and any necessary evaluation and treatment of the primary lesion. For this reason the transthoracic route is reserved for certain cases of marginal ulcer, particularly when incomplete vagotomy has been done previously by the subdiaphragmatic approach.

Technique of Transthoracic Vagotomy (Dragstedt) (Figs. 406, 407)

The left side of the chest is entered through the eighth intercostal space or through the bed of the eighth rib. The intercostal nerve is isolated at the posterior end of the wound, divided and ligated with silk to minimize postoperative pain. The inferior pulmonary ligament is cut and ligated, and the incision in the parietal pleura is extended backward toward the aorta a distance of about 2 to 3 cm. Through the wound

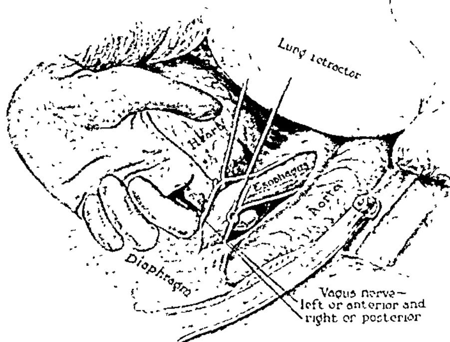


FIGURE 406. Technique of transthoracic vagotomy The esophagus has been mobilized and the nerves identified. A communication is here shown between the anterior and posterior trunks (Dragstedt: Ann. Surg., Vol. 122, J. B Lippincott Company.)

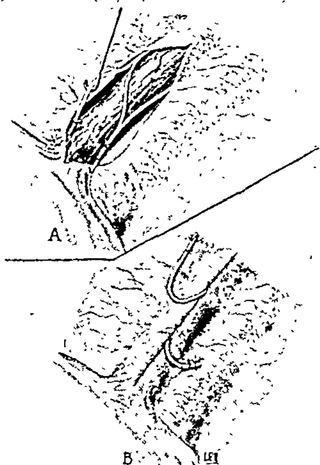


FIGURE 407. Technique of transthoracic vagotomy (*continued*) *A*, The vagus nerves have been severed and ligated with fine silk just above the diaphragm *B*, Proximal ends of the severed nerves sutured to the parietal pleura. (Dragstedt· Ann. Surg , Vol 122, J. B. Lippincott Company.)

in the pleura the esophagus is mobilized by blunt dissection. When the esophagus is lifted, the vagus nerves can usually be seen. Palpation will aid in identification of the nerves.

Both nerves are divided near the diaphragm and ligated with fine silk. The wound in the pleura is closed loosely with interrupted sutures, and the proximal ends of the nerves are sutured to the parietal pleura to prevent regeneration. The chest wound is closed in the routine fashion.

Technique of Subdiaphragmatic Vagotomy (Dragstedt) (Figs. 408, 409)

A vertical or transverse incision is satisfactory. There is considerable individual difference in the ease with which the esophagus can be exposed. A large abdominal retractor such as that described by Weinberg simplifies exposure. The left triangular ligament of the liver may be divided, permitting retraction of the left lobe of the liver to the right. The peritoneal reflection anterior to the esophagus is divided, and the

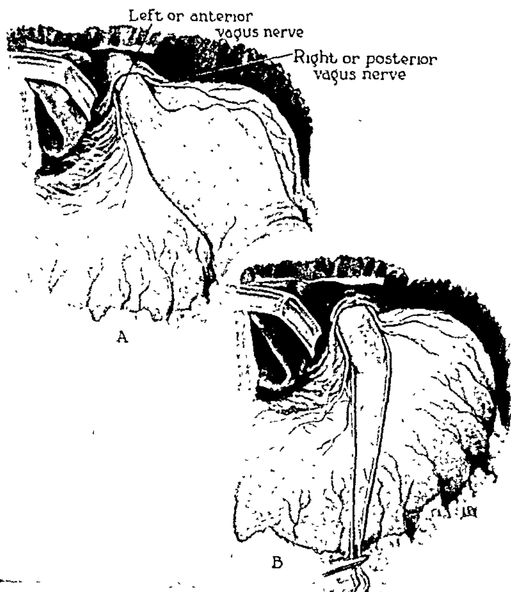


FIGURE 408. Technique of subdiaphragmatic vagotomy. Steps in mobilization of the esophagus and isolation of the vagus nerves (Dragstedt. Ann. Surg, Vol. 122, J B. Lippincott Company.)



FIGURE 409. Technique of subdiaphragmatic vagotomy (*continued*). *A*, The nerves have been isolated and are ready for section and ligation. *B*, The nerves have been divided and ligated, and the proximal ends have been sutured to the diaphragm. (Dragstedt. Ann. Surg., Vol. 122, J. B. Lippincott Company.)

esophagus is exposed by blunt dissection. All small bleeding vessels are ligated as the dissection proceeds to maintain a clear field. By finger dissection and traction from 5 to 7 cm. of the esophagus can be exposed. Traction on the esophagus aids in identification of the nerves by palpation.

The left, or anterior, vagus nerve lies along the lesser gastric curvature. It may be divided into several branches. The right, or posterior, vagus lies along the greater curvature Both main nerves are divided at the cardia, and dissected from the esophagus through the diaphragm. The nerves may be cut, ligated, and permitted to retract into the mediastinum, or the ends may be sutured to the under surface of the diaphragm. All nerve fibers must be removed from the esophagus for a distance of 2 to 3 cm., and all fibers passing to the stomach through the diaphragm must be divided. The wound in the peritoneum may be sutured, and the left lobe of the liver is released.

TOTAL GASTRECTOMY

General Considerations

The operation of total gastrectomy has a limited application. Malignant lesions of the stomach, which constitute about the only indication for complete removal of this organ, are so frequently associated with metastases that operation is useless. The operation must be considered essentially palliative and is usually done to prolong life and to lessen the discomfort of the disease while life lasts. The exceptional case may be cured. In most cases a small pouch of the gastric fundus can be left without jeopardizing the chances of cure and much of the postoperative disability often associated with total gastrectomy avoided. Linitis plastica or leather-bottle type of carcinomatous stomach and certain types of sarcoma with extensive involvement of the stomach wall without demonstrable metastases are the malignant lesions which are most frequently suitable for complete gastrectomy. The most satisfactory exposure can be obtained with a combined abdominothoracic incision. The abdominal portion is made first to determine operability, and the incision is then extended across the left costal margin either intercostally or by excision of a rib.

Technique of Operation (Lahey) (Figs. 410, 411)

A long left rectus incision is made with additional cross incisions when necessary for adequate exposure. The incision used by Clute is satisfactory. The left lobe of the liver is detached from the diaphragm, protected with a gauze pad and retracted to the right with a broad-bladed retractor.

The stomach is freed by ligating and severing all vessels along the greater and lesser curvatures from the duodenum to the esophagus. Injury to the splenic vessels must be avoided where the greater curvature overlies the spleen. Bleeding at this point might be difficult to control without doing a splenectomy. The duodenum is divided between clamps, and the distal end is turned in with catgut sutures reinforced by interrupted sutures of silk. The stomach is wrapped in gauze, turned up and used as a tractor until the esophagus is securely attached to the jejunum. Transverse flaps of diaphragmatic peritoneum are constructed both anterior and posterior to the lower end of the esophagus The flaps are to be utilized later to suture to the jejunum below its line of attachment to the esophagus to take the weight of the jejunum off the anastomosis.

After freeing the peritoneal flaps, the cellular tissues about the lower end of the esophagus are wiped upward with gauze until 5 to 7 cm. of the intrapleural esophagus are drawn down. A long loop of jejunum is brought up over the transverse colon and attached to the posterior wall of the turned-up esophagus with interrupted silk sutures. A suture of silk with the ends left long for traction is first placed at each end of the suture line and held taut while the interrupted sutures are placed. Care must be taken not to make the anastomotic opening between the esophagus and jejunum so small that later constriction may result.

An incision is next made in the jejunum to correspond to the width of the esophagus when the traction sutures are pulled apart. Intestinal clamps are not necessary. A small incision is first made in the esophagus and a suction tip introduced to remove all secretions. The incision in the esophagus is then extended to correspond to the

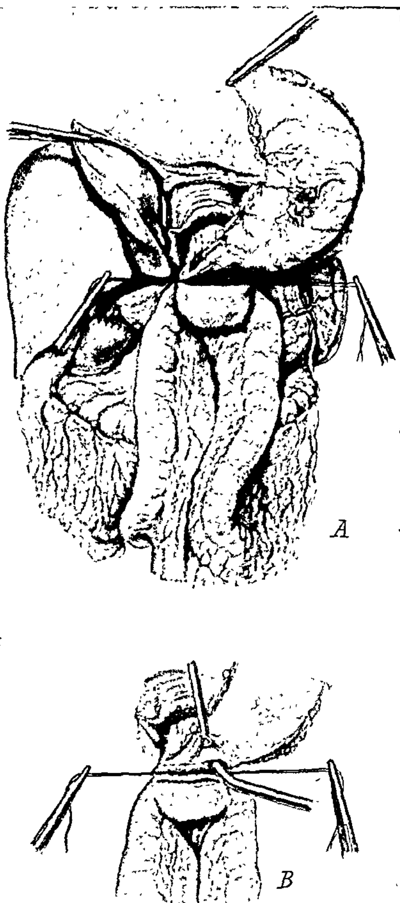


FIGURE 410. Technique of total gastrectomy *A*, Stomach and lower end of esophagus mobilized. Stomach left attached for traction. Jejunum attached to esophagus with 2 traction sutures. *B*, First row of interrupted silk sutures completed Esophagus opened and gastric contents aspirated. (*See continuation of figure on next page.*)

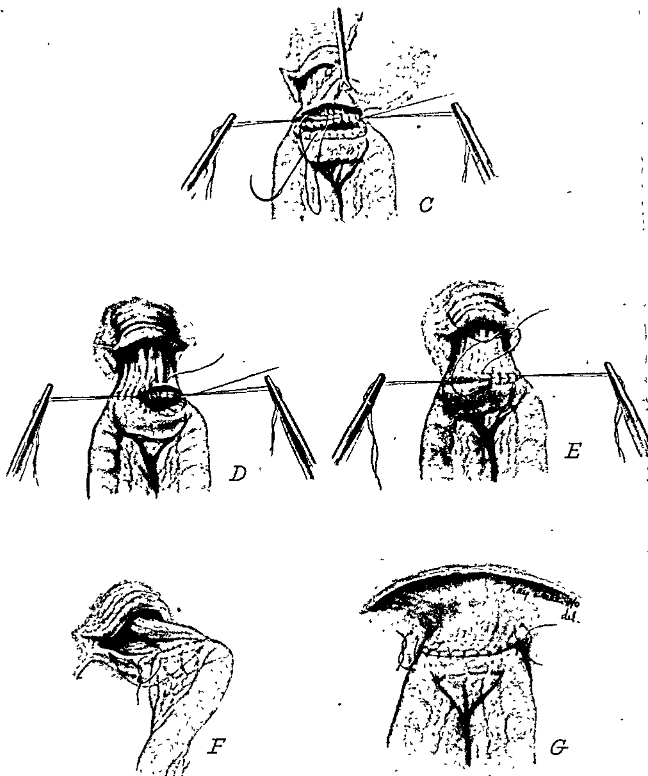


FIGURE 411 Technique of total gastrectomy (*continued*). *C*, Second posterior row of lock-stitch sutures *D*, Anterior interior row of Connell sutures being placed. *E*, Anterior exterior row of interrupted sutures being placed. *F*, Posterior flap of diaphragmatic peritoneum is sutured to the jejunum. *G*, Anterior flap of diaphragmatic peritoneum sutured to jejunum to relieve tension of sutures in esophagus (Redrawn from Lahey: Surg , Gynec. & Obst)

opening in the jejunum. The posterior margin of the esophagus and jejunum is sutured with a lock-stitch the length of the incision in both structures. The double row of sutures will prevent retraction of the esophagus. The stomach is completely removed by cutting across the anterior esophageal wall. The posterior row of catgut sutures is continued as a Connell suture uniting the anterior walls of the esophagus and jejunum. Traction is made on the two silk guy sutures to maintain the caliber of the anastomosis. An anterior row of interrupted silk sutures completes the anastomosis.

The next important step is the attachment of the reflected peritoneal flaps to the jejunum below the anastomosis. This is done with interrupted silk sutures The jejunum is attached to the diaphragm by silk sutures to further protect the anastomosis *from traction. Enteroenterostomy is not considered necessary. The abdominal wound* is closed without drainage.

The Lahey technique of total gastrectomy is described primarily for its historical interest. Its use is not recommended, however, since it does not fulfill the requirements of a cancer operation.

Technique of Operation (Orr) (Figs. 412 to 415)

A left paramedian incision is made from the angle between the ensiform process

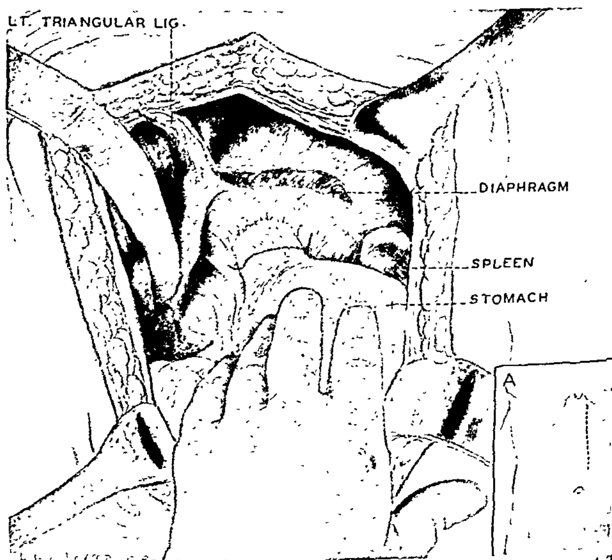


FIGURE 412 Technique of total gastrectomy. Type of abdominal incision shown in inset. *A*, The left triangular ligament of the liver has been severed and sutured to the right abdominal wall to retract the left lobe of the liver. Line of incision in the peritoneum for exposure of the esophagus.

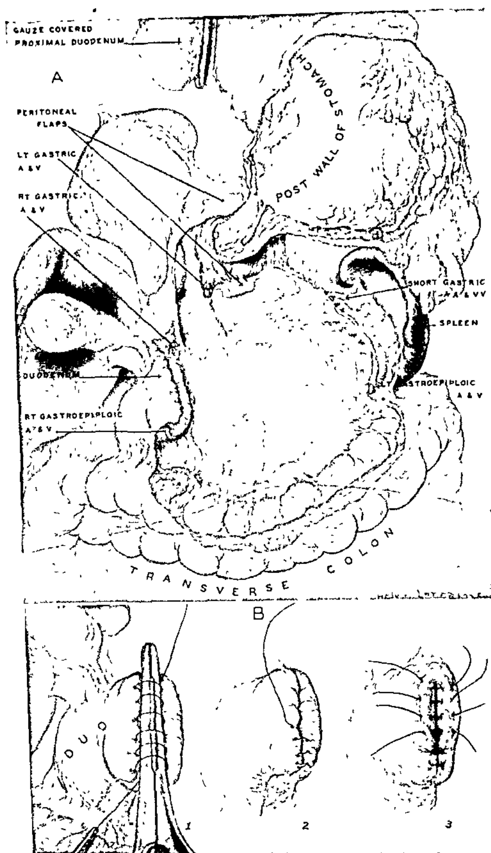


FIGURE 413 *A*, Technique of total gastrectomy (*continued*). The stomach and omentum have been freed and retracted. The esophagus is exposed, ready for anatomosis. *B*, Method of closure of the duodenum with 2 rows of continuous catgut sutures and third row of interrupted silk Lembert sutures.

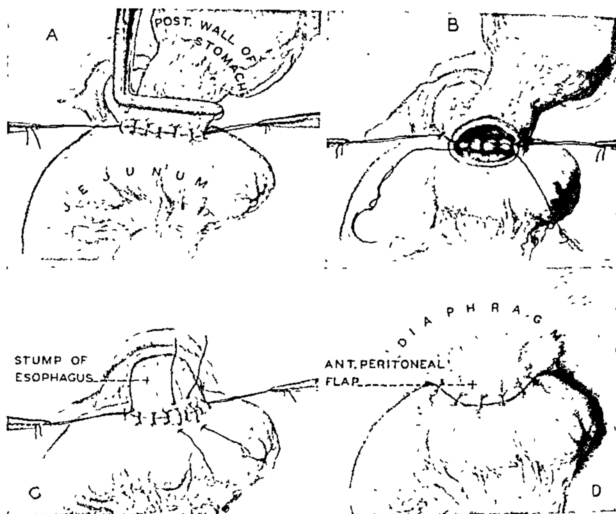


FIGURE 414. Technique of total gastrectomy (*continued*). The jejunum has been divided about 15 cm. below the ligament of Treitz and the distal end closed *A*, *B*, *C*, *D*, Steps in the technique of anastomosis of the esophagus to the jejunum.

and the costal margin to a point 4 to 6 cm. below the level of the umbilicus. Careful exploration is imperative to determine operability before dissection is begun.

To increase exposure of the esophagus, the left hepatic ligament is severed and sutured beneath the right abdominal wall to displace the left lobe of the liver to the right. Peritoneal flaps are made, and the esophagus is carefully explored to ensure adequate length below the diaphragm for anastomosis. Examination is again made for extension of the tumor or metastases in the region of the esophagus. The duodenum is freed and divided between Ochsner clamps, removing a liberal amount of duodenum. The severed pyloric end is covered with gauze to prevent soiling. The distal end of the duodenum is closed with two rows of no. 00 chromic catgut reinforced with a row of Lembert sutures of fine silk. With the pyloric end of the stomach used for traction, the gastrohepatic ligament is divided and ligated as far away from the stomach as possible, and the great omentum is completely removed with the gastrocolic ligament. When the spleen is approached, the splenic vessels are divided and ligated as near the spleen as possible. The spleen may be removed if there is any infiltration of tumor tissue along the vessels or if there is troublesome bleeding. By retraction of the stomach upward the vessels near the cardia are easily exposed and ligated. The vagus nerves are divided to increase exposure of the esophagus. All areolar tissue is carefully removed from the lower end of the esophagus.

By gentle, blunt finger dissection, the esophagus may be freed through the hiatus and exposed a distance of 5 to 8 cm. below the diaphragm.

The indwelling gastric suction tube is withdrawn into the esophagus, and a right-angled clamp is placed across the esophagus at the cardia. By placing the clamp transversely, the esophagus is flattened and widened near the suture line to aid in the construction of as large a stoma as possible.

The jejunum is divided between clamps about 15 to 20 cm. below the ligament of Treitz, and the proximal end is covered with gauze and held for future anastomosis. The distal end of the jejunum is closed with two rows of no. 00 chromic catgut sutures

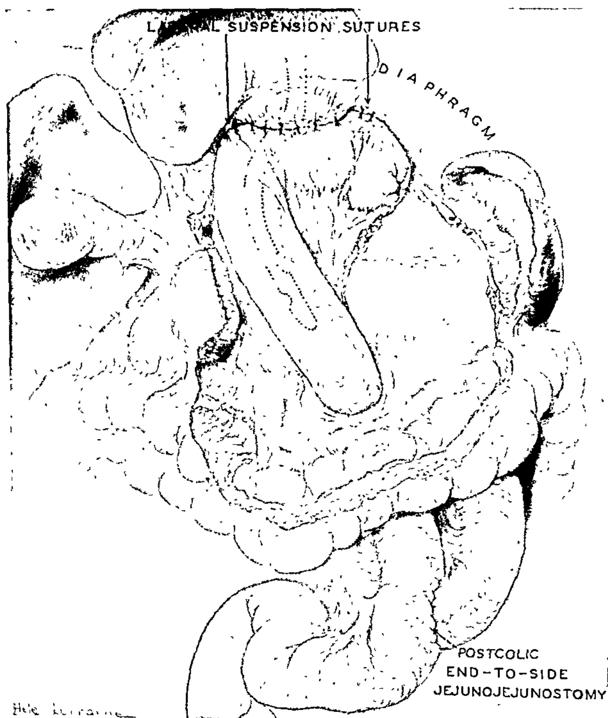


FIGURE 415. Technique of total gastrectomy (*concluded*). Anastomosis of esophagus to jejunum and end-to-side jejunojejunostomy completed. A tube is shown passed through the esophagojejunostomy stoma.

reinforced with a row of Lembert sutures of silk. The distal segment is drawn through an opening made in the mesocolon, or placed anterior to the colon, and anastomosed to the esophagus 5 to 6 cm. distal to its closed end. An end-to-end anastomosis between the esophagus and jejunum may be used. Interrupted silk stitches are used for the first row of sutures. The end sutures are left long for traction. Incisions of equal length are made in the esophagus and jejunum about 4 mm. from the suture line, and the posterior wound margins are united with a lock-stitch of chromic catgut. The anterior wall of the esophagus is next divided, and the stomach is removed. Soiling is prevented by suction. The anterior margins of the wound are united with a lock-stitch while traction is maintained on the tension sutures. An anterior row of interrupted silk sutures completes the anastomosis.

The line of anastomosis is covered with the previously constructed peritoneal flaps, and the jejunum is sutured to the diaphragm on each side of the anastomosis with three or four interrupted sutures of silk to suspend the jejunum and decrease the tension on the line of anastomosis. When the anastomosis is completed, the tube in the esophagus is passed a few centimeters into the jejunum. The suture in the left hepatic ligament is cut to release the left lobe of the liver.

An end-to-side anastomosis is made between the proximal end of the severed jejunum and the distal segment of the jejunum below the mesocolon. The mesocolon is closed about the jejunum and its mesentery.

The abdominal wound is closed with steel wire. Drainage is usually advisable. Small quantities of liquid may be given through the indwelling tube for four or five days. The tube is then removed, and liquid feedings are begun.

CLOSURE OF GASTROENTEROSTOMY

The site of the gastroenterostomy is located and its relation to the transverse colon determined. The anastomosis is approached through the transverse mesocolon. Injury to the large vessels in the mesocolon must be avoided to prevent gangrene of a section of the transverse colon. The adhesions about the stoma are separated and the colon freed if adherent. After placing protecting gauze packs about the operative field, the anastomosis is severed between rubber-shod intestinal clamps. Soiling is prevented by careful suction cleansing. The stomach is closed longitudinally and the jejunum transversely with fine chromic catgut for the mucosal and with fine silk for the seromuscular sutures. A resection of the jejunum with end-to-end or lateral anastomosis may be necessary in some cases. The mesocolon is closed with catgut.

CLOSURE OF GASTROJEJUNOCOLIC FISTULA

General Considerations

After simple gastroenterostomy or gastric resection a jejunal ulcer may form and perforate the transverse colon. This type of fistula causes a profound disturbance of the physiology of the gastrointestinal tract and state of nutrition of the patient which usually results in death if not corrected by surgical operation. To effect a cure, the continuity of the stomach, jejunum and colon must be re-established. Choice of opera-

tion must be decided after the abdomen has been explored. The simplest procedure is separation of the three organs from each other with closure of the opening in each. If the pylorus is patent, simple closure of the openings may be sufficient. A much more elaborate operation is usually necessary. If the gastroenterostomy is disconnected in the presence of a pyloric stenosis, a pyloroplasty or partial gastrectomy is advisable.

Dangers and Safeguards

An operation to close a gastrojejunocolic fistula may be one of the most difficult in abdominal surgery. Fortunately such complications are rare today. The mortality rate has been estimated as 10 to 40 per cent. The patient is usually starved, dehydrated and anemic, presenting a poor risk for such a formidable operative procedure. For this reason a diverting colostomy proximal to the colonic portion of the fistula may be necessary as a preliminary operation to permit improvement of the general condition of the patient.

Preparation of the colon with antimicrobial drugs has greatly decreased the hazards of peritonitis and wound infection.

Technique of Operation

If the patient's general condition permits, this may be accomplished as a one-stage operation; however, it may be necessary to do a preliminary diverting colostomy as a first-stage procedure to permit improvement of the general condition of the patient before excision of the fistula as a second-stage procedure. When this is done, a third-stage operation for closure of the diverting colostomy is necessary. Careful mechanical cleansing of the colon as well as preparation with antimicrobial agents is essential.

The abdomen may be entered through the scar of the previous incision, or an

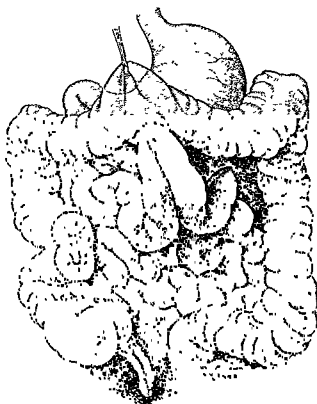


FIGURE 416. Three-stage operation for gastrojejunocolic fistula Exploration of lesions and loop colostomy in ascending colon or at hepatic flexure (Pfeiffer. Surg, Gynec. & Obst, Vol. 72 By permission of Surgery, Gynecology and Obstetrics.)

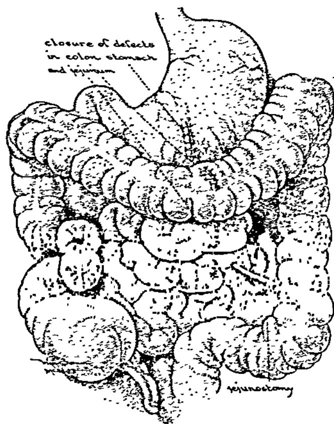


FIGURE 417. Three-stage operation for gastrojejunocolic fistula (*continued*). Second stage, first method. Repair of defects in stomach, colon and jejunum. Jejunostomy optional (Pfeiffer: Surg , Gynec. & Obst., Vol 72. By permission of Surgery, Gynecology and Obstetrics.)

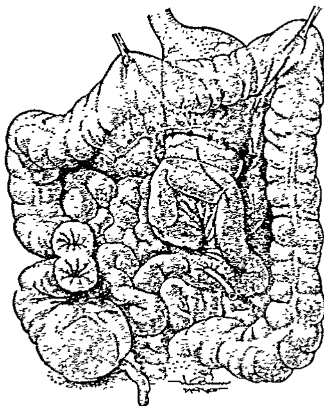


FIGURE 418. Three-stage operation for gastrojejunocolic fistula (*continued*). Second stage, second method (preferred). Polya partial gastrectomy, excision of fistula and repair of jejunum. Jejunostomy. (Pfeiffer: Surg , Gynec & Obst., Vol. 72. By permission of Surgery, Gynecology and Obstetrics.)

entirely new incision may be preferred. The transverse colon, jejunum and stomach are freed of adhesions to expose the area about the fistula. At this point a decision must be reached as to what type of procedure is indicated to avoid further ulcer difficulty. If the complication has followed simple gastroenterostomy, subtotal gastric resection to avoid reactivitation of the original ulcer may be desirable. In some in-

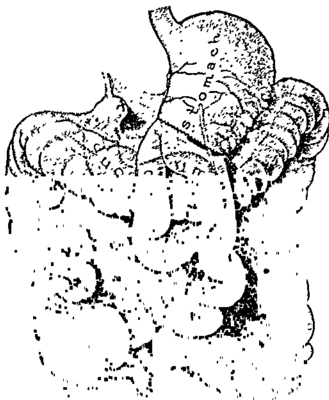


FIGURE 419. Three-stage operation for gastrojejunocolic fistula (*concluded*). Second stage. Subtotal gastrectomy; anterior gastrojejunostomy by Polya or Hofmeister method. (Pfeiffer, Surg., Gynec. & Obst., Vol. 71. By permission of Surgery, Gynecology and Obstetrics.)

stances it may be desirable to combine vagotomy with the procedure, in which event the vagotomy should be done before opening the fistula or colon.

When the fistula and surrounding stomach, jejunum and colon have been isolated, each of these organs is separated from the site of the fistula. It may be possible to isolate any of the three structures involved from the fistula and close the resultant defect. In other instances it may be necessary to remove the segment of jejunum and colon involved and re-establish continuity by end-to-end anastomosis. If subtotal gastric resection is to be done, this is carried out by any of the standard methods of gastric resection.

CONGENITAL HYPERTROPHIC PYLORIC STENOSIS

Dangers and Safeguards

Infants requiring operation for congenital pyloric stenosis are usually two to six weeks old. If vomiting has persisted for several days and the child is losing weight, operation may be hazardous. A marked alkalosis and hypochloremia may develop. Such depleted patients should be given sodium chloride solution and a small transfusion before operation. Medical treatment should not be prolonged in patients with complete obstruction, since operation is the only means of obtaining permanent relief.

There are few surgical procedures which give more gratifying results than operation for relief of congenital pyloric stenosis.

Feeding can be started soon after operation, and prompt improvement may be expected. If postoperative vomiting occurs, the stomach should be lavaged. Liquids taken by mouth should be supplemented by hypodermoclysis of physiologic sodium chloride solution for the first two or three days.

The Fredet-Ramstedt operation is simple and gives a permanent cure. The results of this operation are so satisfactory that no other technique will be described.

Technique of Operation (Fredet-Ramstedt) (Fig. 420)

A local anesthetic, using 0.5 per cent procaine, is satisfactory in many cases. A pacifier sweetened with sugar aids in quieting the patient. Ether anesthesia may be used with safety.

Robertson uses a muscle-splitting incision. The skin incision is made parallel to and 2 cm. below the right costal margin, extending outward from the margin of the right rectus muscle. The external and internal oblique muscles are split in the direction of their fibers, as in the McBurney incision. The transversalis fascia and peritoneum are usually incised together. This incision is located directly over the pylorus and affords easy exposure. Danger of late disruption is almost nil. Some prefer a vertical right rectus incision.

The stomach wall is grasped with gauze between the fingers and drawn into the wound, where it is held by an assistant. With the left hand, the operator is then able to grasp the pyloric tumor between the thumb and finger and hold it freely exposed in the wound until the operation is completed. The serosa and superficial fibers are incised across the tumor, using great care not to enter the duodenum or stomach. With

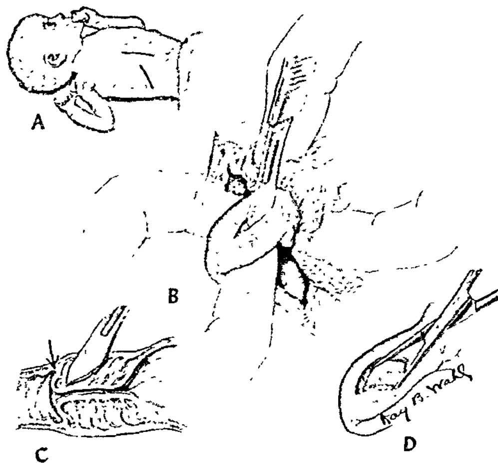


FIGURE 420. Technique of operation for congenital pyloric stenosis. *A*, *Incision* The subcostal incision is preferred. *B*, Tumor delivered and held with thumb and finger of left hand while muscle is divided *C*, Cross section of tumor, illustrating why extreme care must be taken while incising tumor at the duodenal edge to prevent penetration of the mucosa. *D*, Separation of muscle to expose mucosa layer.

a small pointed hemostat, the margins of the wound are spread apart, breaking the circular muscular fibers down to the mucosa. When the constricting fibers are severed, the mucosa will bulge into the incision throughout its length. The danger point is at the junction of the pyloric ring with the duodenum, where the latter forms a sulcus about the distal end of the ring as it protrudes slightly into the duodenum much as a cervix extends into the vagina. If the duodenum is opened, it can be closed easily with fine sutures of chromic catgut or silk with little danger of subsequent leakage. There is little bleeding, and usually no ligatures or sutures are required. A portion of omentum is sutured over the incision, using a fine curved intestinal needle threaded with fine catgut or silk. The fascial layers of the abdominal wound are closed with fine chromic catgut or silk and the skin with silk.

Operations upon the Liver

General Considerations

Because of the position of the liver above the costal margins, surgical exposure is difficult. It may be approached by a transpleural incision through the chest wall, extraperitoneally below the costal margin posteriorly, or through the abdomen. The choice of approach depends upon the location of the disease. If the lesion cannot be located preoperatively, a paramedian or right *rectus incision* is preferable. This may be enlarged by cutting across the rectus muscle in either direction as conditions indicate. An incision along the right costal margin extending outward from the midline is useful for exposing the right lobe of the liver. A chondroplastic or costochondroplastic operation may be added to this incision to increase a transperitoneal exposure (Fig. 421).

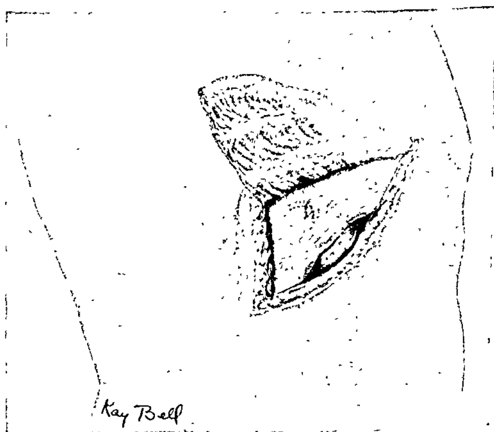


FIGURE 421 Exposure of liver margin Kocher type of incision plus the formation of a chondroplastic flap (Redrawn from Bickham's Operative Surgery.)

TRAUMATIC WOUNDS OF THE LIVER

Dangers and Safeguards

Because of the vascularity of the liver, traumatic wounds of this organ present an important problem in the *control of bleeding*. Death results in many cases before surgical intervention is possible. As a result of hemorrhage and shock, patients are frequently poor operative risks. If there has been extensive pulpification of the liver, a toxic state often develops in a few days, manifested by a rise in the nonprotein nitrogen and creatinine of the blood, producing what has been described as a "hepatorenal syndrome."

Early operation is indicated when liver trauma with hemorrhage is suspected.

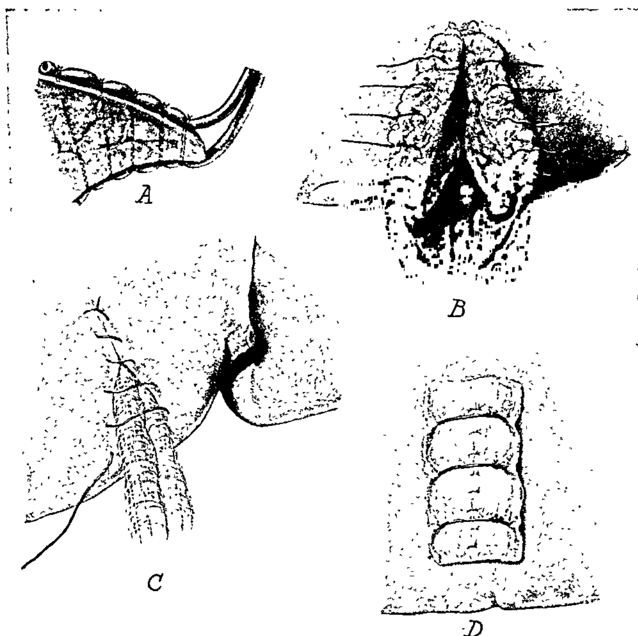


FIGURE 422 Methods of closing wounds of the liver due to trauma. *A*, Sutures placed over rubber tubing at wound margins. Tubing projects through abdominal wound and is removed later. *B*, Omentum sutured over wound margins. *C*, Sutures placed over gauze pack in wound. *D*, Through-and-through sutures placed through fascia.

The operative approach is through the abdomen. After the abdomen has been opened hemorrhage can be controlled for short periods by grasping the vessels in the hepatoduodenal ligament. The portal vein and hepatic artery are compressed between the thumb and two fingers passed through the foramen of Winslow. A rubber-covered intestinal clamp may also be used for this purpose. This procedure should be done with caution, since shock may be produced, and damming back of portal blood may damage the intestine after fifteen to twenty minutes. Bleeding may be reduced by injecting the liver substance with physiologic sodium chloride solution containing epinephrine.

Hemostatic agents such as *gelatin sponge* may be used to control the bleeding from liver wounds. Jenkins and Janda have been able to control excessive venous hemorrhage with the gelatin sponge (Gelfoam) in experimental liver resections. The gelatin sponge should be moistened with physiologic saline solution and applied with even pressure over the bleeding area for three to five minutes. A wound in the liver may be sutured over a gelatin sponge applied to the bleeding surface. Excessive quantities of the hemostatic agent should not be used, especially in wounds that are likely to become infected.

Technique of Liver Suture

An incision is made parallel to the costal margin or through the rectus muscle. The wound in the liver is usually located by palpation. Liquid blood and blood clots are removed by sponging and suction to clear the operative field. Through-and-through sutures of heavy catgut may successfully control the bleeding. Since the normal liver substance is very friable, mattress sutures passed around rubber tubing, through strips of fascia or omentum, may be necessary to prevent further tearing of the liver tissue (Fig. 422). Vessels may be grasped and ligated. Veins are very thin-walled and friable.

In some cases it may be necessary to pack the liver wound with gauze to control bleeding. Sutures may be added to hold the gauze in place. After five or six days the gauze may be cautiously loosened and removed piecemeal from day to day. Infection is not an uncommon complication of this type of treatment.

LIVER ABSCESS

General Considerations

Liver abscesses are usually pyogenic and multiple or amebic and solitary. Multiple pyogenic abscesses are not amenable to surgical treatment. Occasionally such abscesses may coalesce, forming one or more large pus collections which may be drained. The mortality rate of pyogenic abscess is high even when drainage is possible. There may be difficulty in distinguishing true liver abscess from subphrenic abscess. The methods of operative approach differ little in the two conditions (Fig. 423). A liver abscess may rupture through the diaphragm and form an empyema or bronchial fistula Amebic abscesses, unless secondarily infected, can usually be cured by medical treatment with emetine and multiple aspirations, although the danger of secondary infection associated with surgical drainage of these lesions has been minimized with the availability of the antimicrobial drugs.

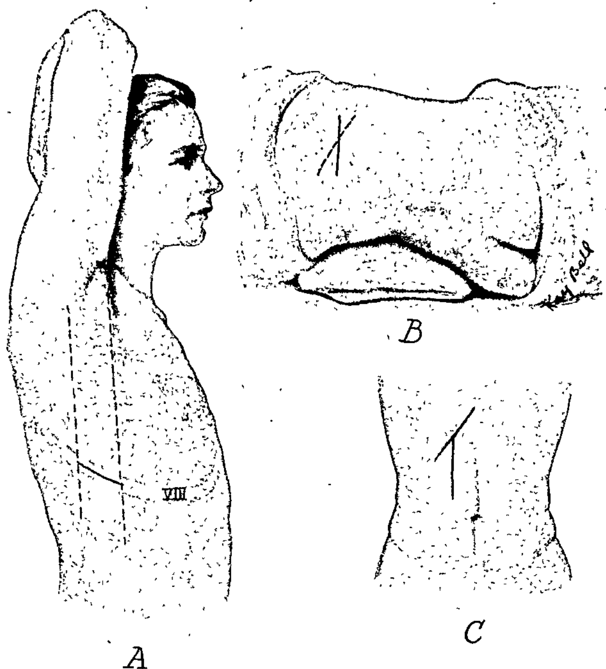


FIGURE 423. Incisions for drainage of liver abscess. *A*, Transpleural *B*, Subphrenic. *C*, Oblique of Kocher and right transrectus.

Dangers and Safeguards

Aspiration of a liver abscess is not without danger because of the possibility of infecting the pleura or peritoneal cavity. After exposure of the liver and protection of these serous cavities the abscess may be accurately located by aspiration. Danger of infecting the pleura or peritoneum also accompanies operation for abscess drainage.

Operation should never be extensive or prolonged. Transfusions should be freely used when there is secondary anemia or marked toxemia.

Technique of Transpleural Drainage

Local anesthesia is usually indicated. An incision 8 cm. long is made over the eighth rib in the midaxillary line. About 6 cm. of the seventh and eighth or eighth and

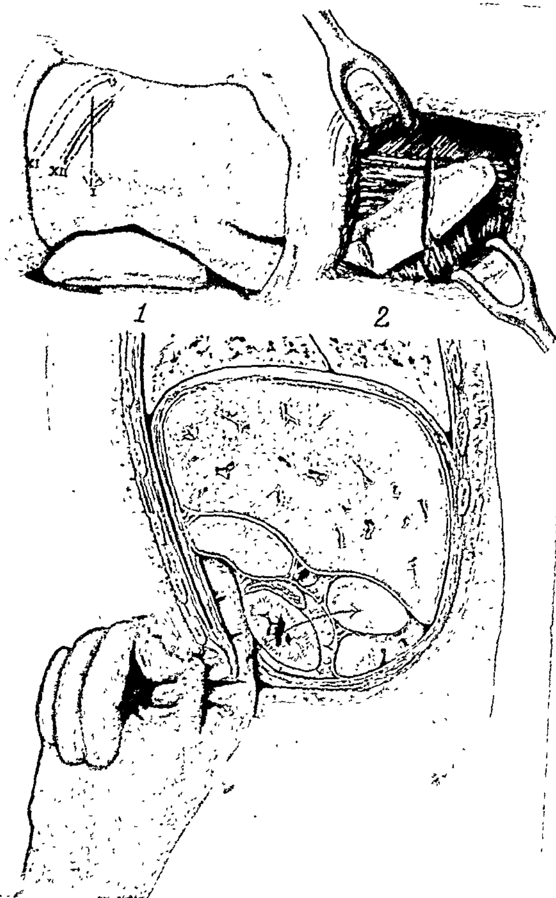


FIGURE 42 ue of drainage of subpl atic absce for po
extrapleural a phrenic or subhepa ion thro
of twelfth rib. on to abscess bene drawn
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ninths ribs are excised subperiosteally. The pleura is exposed and freed beneath the rib-resected area. Interrupted or continuous catgut sutures are placed which firmly approximate the costal and diaphragmatic pleurae. An incision is made through the diaphragm to expose the liver. If the free peritoneal cavity is opened, its parietal and visceral layers should be closed by sutures. If there is any doubt about the exclusion of the pleura or peritoneal cavities, the wound should be packed with gauze for four or five days before draining the abscess. The abscess cavity should be drained with one or two large rubber tubes sutured to the skin with silk to retain them in position.

Technique of Subpleural Drainage

An incision is made below and parallel to the twelfth rib. A better exposure may be obtained by completely resecting the twelfth rib as described for drainage of subphrenic abscess (Fig. 424). The margin of the erector spinae muscle is identified, and by blunt dissection the liver is approached through the perirenal fat and fascia. If the peritoneum or pleura is opened, it is advisable to pack the wound firmly with gauze until adhesions have formed to seal the exposed serous cavity. In four or five days the gauze is removed and the tract followed to the liver by blunt or careful cautery dissection.

Technique of Transperitoneal Drainage

If there is any bulging below the costal margin, the abdominal incision should be made at that point. It may be made parallel to the ribs or through the rectus muscle. If considerable exploration is contemplated to locate the abscess, an incision of the Singleton type gives good exposure (Fig. 424). Adhesions about the liver which exclude the peritoneal cavity should be preserved. If there are no adhesions, the peritoneum must be carefully protected with gauze packs. After locating the abscess, a gauze pack placed in the wound against the liver to be removed in four or five days is often the safest method. The abscess is usually located with an aspirating needle which may be followed with knife, scissors or cautery to effect drainage. Rubber-tube drainage is desirable so that the cavity may later be irrigated.

OPERATIONS FOR SUBPHRENIC ABSCESS

Dangers and Safeguards

At least 50 per cent of subphrenic infections resolve without abscess formation. When an abscess develops beneath the diaphragm, the treatment is surgical. The nonoperative treatment has a forbiddingly high mortality rate and should not be continued after the diagnosis is made. In general, the earlier the operative treatment, the lower the mortality rate. If operative treatment is delayed, complications may develop, particularly those within the thorax which make therapy more difficult and increase the death rate. The mortality rate is higher when drainage is made transpleurally or transperitoneally as compared to retroperitoneal drainage without contaminating either the pleura or peritoneum.

Attempts to locate pus beneath the diaphragm by aspiration are condemned as likely to infect the pleural or peritoneal cavities. After the conclusion has been reached that a subdiaphragmatic abscess exists it is safer and more conclusive to explore the subphrenic space.

The immediate dangers of operation are shock and contamination of the pleural and peritoneal cavities. A careful study of each case in an effort to locate the abscess as accurately as possible before operation will enable the surgeon to make his incision at a point which is least likely to spread infection. Local anesthesia usually suffices in most cases. One of the gas anesthetics may be used if necessary.

Technique of Retroperitoneal Incision and Drainage (Ochsner and Graves) (Figs. 424, 425)

The patient is placed on the unaffected side on either a kidney rest or sandbag so that a scoliosis of the lower dorsal and lumbar spine is produced. An incision about 8 to 10 cm. long is made over and parallel to the twelfth rib. The entire twelfth rib is resected subperiosteally. This should be done carefully to avoid puncture of the pleura, which may extend beneath the proximal portion of the rib. The erector spinae muscles are retracted medially, and a transverse incision is made at a right angle to the vertebrae across the bed of the resected rib at the level of the spinous process of the first lumbar vertebra. *This transverse incision should be accurately located* as described *so that it will fall below the level of the pleura in the costophrenic angle.* This incision passes through the bed of the twelfth rib and the attachment of the diaphragm, exposing the renal fascia.

The kidney is displaced downward by blunt finger dissection, and the infrahepatic space is gently palpated. If induration is encountered in this locality, aspiration should be done in an effort to locate an abscess. If pus is not found by this maneuver, the right posterior superior space may be entered by separating the peritoneum from the under surface of the diaphragm by means of the finger. The presence of inflammatory edema facilitates this procedure. This dissection may be carried upward to the dome of the liver or until the abscess is reached and entered. The finger can usually be easily plunged through the abscess wall. Two large, soft, fenestrated rubber tubes are passed into the cavity and fixed to the skin margins with loose sutures. The wound is closed loosely about the drainage tubes with silk.

Abscesses in the right anterior superior, the right inferior, the left anterior inferior and the left superior spaces may be drained extraperitoneally through the anterior abdominal wall (Fig. 425). An incision is made just beneath and parallel with the costal margin through all the abdominal muscles down to the anterior parietal peritoneum. Through such an incision the peritoneum may be mobilized beneath the ribs and diaphragm by finger dissection until the abscess cavity is reached and opened.

Drainage should be continued until the exudate is thin and much reduced in quantity The capacity of the abscess cavity may be measured by injecting salt solution through a drainage tube. Too early removal of drainage may result in a re-formation of the abscess.

Use of the two-stage transpleural approach for drainage of a subphrenic abscess is rarely indicated.

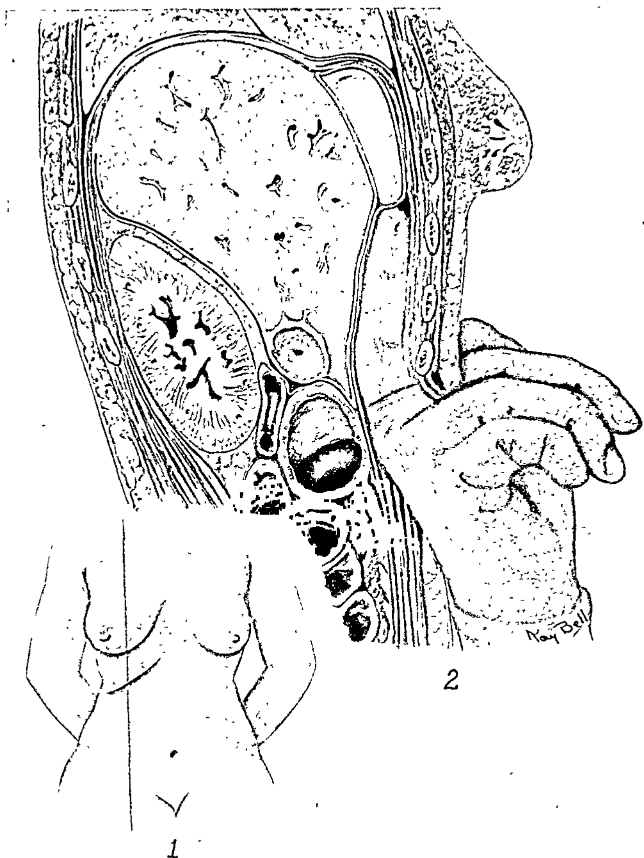


FIGURE 425. Technique of drainage of subphrenic and subhepatic abscesses (*concluded*). *1*, Incision for anterior approach to subphrenic abscess *2*, Extraperitoneal finger dissection to abscess (Redrawn from Ochsner and Graves. Ann Surg)

TUMORS OF THE LIVER

Technique of Operation

An inhalation anesthetic is indicated. An oblique subcostal incision extending across one or both rectus muscles will usually give adequate exposure. A small tumor

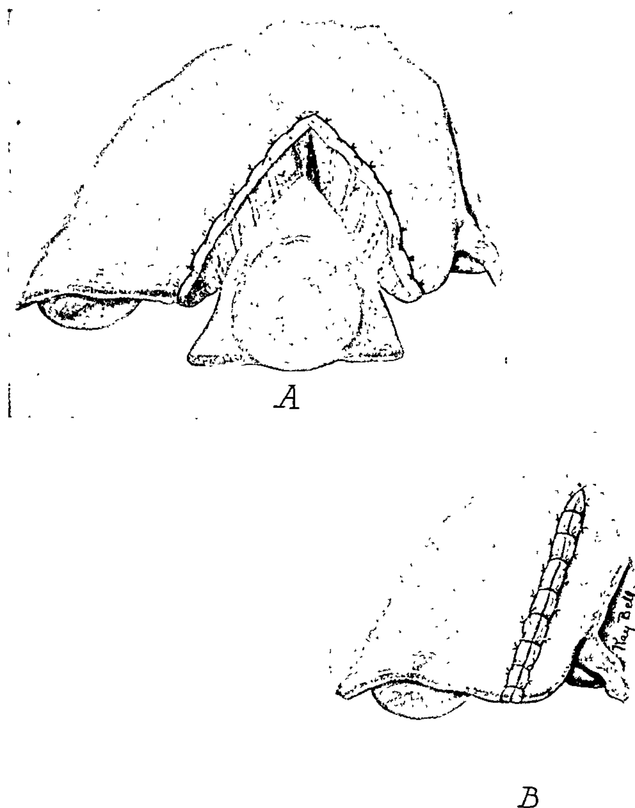


FIGURE 426 Excision of tumor of the liver. *A*, Through-and-through sutures are placed before the tumor is excised *B*, Wound in liver closed by sutures placed to grasp the deep through-and-through sutures

may be removed through a wedge-shaped incision. Such wounds can usually be closed with sutures (Fig. 426). For tumors confined to the left lobe of the liver Pickrell and Clay recommend excision of the entire lobe, which, they say, is more easily and safely accomplished than local excision of a large part of the lobe. These authors mobilize the liver by dividing the falciform ligament near its diaphragmatic attachment. Bleeding is controlled by ligating the left hepatic artery and inserting two rows of mattress sutures of silk in the interlobular sulcus. The left lobe is then removed by cutting between the two rows of sutures. The cut surface of the right lobe is covered with the falciform ligament. The sutures used in the falciform ligament are also used to attach this ligament to the diaphragm. Before excising a large tumor, through-and-through mattress sutures of catgut placed around the tumor will aid in the control of bleeding (Figs. 426, 427, 428, 429).

Bleeding may be difficult to control. Compression of the hepatic artery and portal vein in the hepatoduodenal ligament may quickly produce shock and should be used with caution. Suture ligatures may be used to close large vessels. The cautery is of doubtful value, since it will not control bleeding from large vessels and causes some

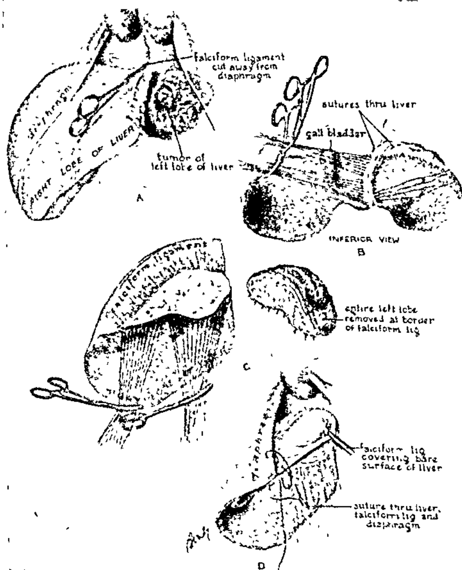


FIGURE 427. Technique of removal of the left lobe of the liver. *A*, *B*, *C*, *D*, Steps in the excision of the left lobe of the liver to remove a large tumor (Pickrell and Clay: Arch. Surg , Vol. 48.)

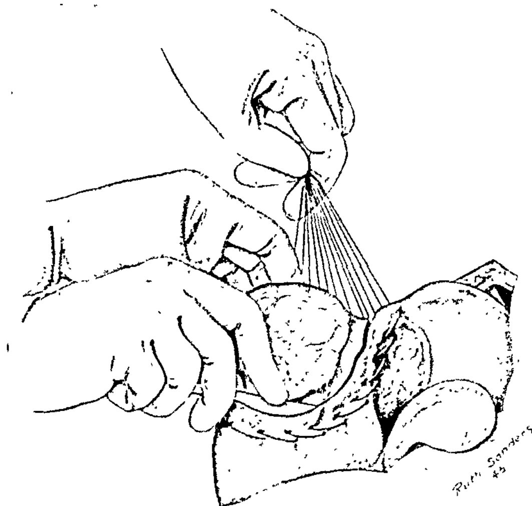


FIGURE 428 Technique of resection of liver tumor. A row of through-and-through interlocking mattress sutures is placed about the tumor and held while the tumor is resected. (Duckett and Montgomery. Surgery, Vol 21, C V Mosby Company.)

necrosis of liver tissue. Packing of the liver with gauze may be necessary in some cases, but is undesirable because it predisposes to infection. The application of fibrin foam or Gelfoam to bleeding surfaces will aid in the control of bleeding. Drainage of the abdomen is indicated, since oozing of blood and bile from the cut surface of the liver frequently occurs.

ECHINOCOCCUS CYSTS

Technique of Operation

Echinococcus cysts are usually approached through the abdominal wall, but occasionally they lie against the diaphragm, making transthoracic operation advisable. In either approach the pleura and peritoneum must be carefully protected as in drainage of liver abscess.

A high Singleton type of incision usually gives good exposure. The abdomen is carefully protected by gauze packs. It is wise to aspirate the cyst completely to prevent soiling. The cyst may be secondarily infected and contaminate the peritoneum. If scolices are present, they may infect the peritoneum. A two-stage operation is often advisable if infection exists. The liver is stitched to the parietal peritoneum and a

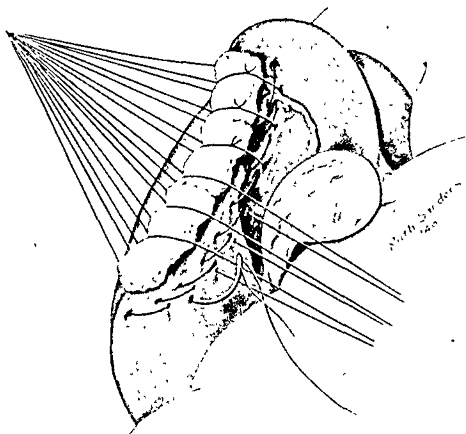


FIGURE 429. Technique of resection of liver tumor (*concluded*). While the ends of the through-and-through sutures are held taut, fibrin foam is placed in the liver defect and held by interrupted sutures passing through the liver and over the mattress sutures. (Duckett and Montgomery Surgery, Vol. 21, C. V Mosby Company)

portion of the wound packed with gauze against the liver surface. In five or six days the gauze is removed and the cyst drained.

Cysts may also be treated by enucleation of the endocyst, complete excision of the cyst, or by marsupialization. The method used must depend upon the size and location of the cyst. Complete removal is the ideal treatment. To marsupialize the cyst, the wall is sutured to the peritoneum, completely emptied by suction or sponging, and packed with gauze. The cyst wall usually separates and can later be removed. Chronic sinuses may persist for months or even years, making secondary operation advisable to remove necrotic material, cyst wall or calcified fragments.

Operations upon the Gallbladder and Bile Ducts

Anatomy

The *gallbladder* usually lies in a fissure of the liver, but in rare cases may have a short mesentery. The fundus is attached at the lower margin of the liver, and the body is directed upward, inward and backward. It measures approximately 7.5 cm. in length by 3 cm. in diameter and has a capacity of 35 to 50 cc. Posteriorly, it is in contact with the first portion of the duodenum and transverse colon. It is attached to the liver and approximately three fourths covered by peritoneum. On the surface it may be located at a point where the right midclavicular line crosses the tip of the ninth right costal cartilage.

The *common hepatic duct* is formed by the right and left hepatic ducts in the portal fissure. It is about 2.5 cm. long and 6 mm. in diameter. The *cystic duct,* which drains the gallbladder, is about 3 cm. long and is smaller than the hepatic duct. The common hepatic and cystic ducts join to form the *common bile duct* (choledochus), which opens into the duodenum. The common bile duct measures about 7.5 cm. in length and 7 mm. in diameter. Approximately one-half of the duct lies above the duodenum and one-half behind it. In more than half of the cases the lower end of the common duct is surrounded by pancreatic tissue. Near its opening into the second portion of the duodenum it expands to form the ampulla of Vater. Here it is joined by the pancreatic duct (duct of Wirsung).

The right and left branches of the hepatic artery supply respectively the right and left lobes of the liver. The right branch usually passes behind the bile ducts, but sometimes in front near the cystic duct. The cystic artery supplying the gallbladder is given off by the right hepatic branch. The common duct, portal vein and hepatic artery lie in the free margin of the gastrohepatic omentum. The common duct lies to the right, the hepatic artery to the left with the portal vein behind and between them (Fig. 430). Behind the free margin of the gastrohepatic omentum is the foramen of Winslow, leading into the lesser peritoneal sac.

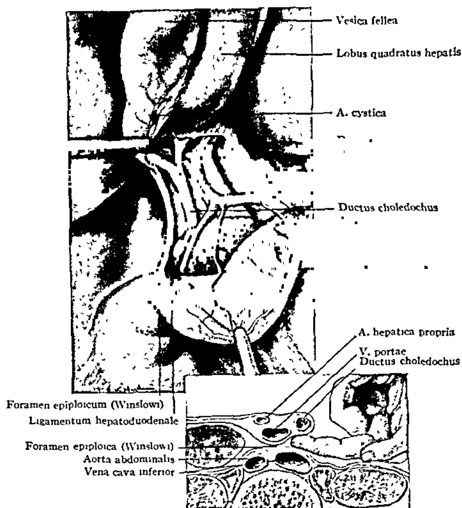


FIGURE 430. Relationship of gall ducts and vessels in hepatic pedicle. The inset shows a cross section of the structures of the pedicle (Callander: Surgical Anatomy.)

Dangers and Safeguards

Proper preoperative and postoperative care of patients saves many lives. This requires a thorough knowledge of the anatomy, physiology and pathology of the biliary tract.

Anomalies of the biliary ducts and regional blood vessels are frequent. Some variation from the normal may be expected in approximately 25 per cent of patients. To avoid accidents, adequate exposure and recognition of each anatomical structure are essential. It should be the rule that *no gallbladder be removed until the common hepatic duct, cystic duct and common duct are identified.* Injury to the common duct, common hepatic duct or portal vein may result if this rule is not observed. It is wise to advise young surgeons *to visualize and identify everything before cutting anything.*

Bleeding may be avoided by freeing and ligating the cystic artery separate from the cystic duct. If bleeding occurs, blind and hasty grasping for the bleeding point endangers nearby structures. The bleeding vessel can be identified by careful sponge pressure to control the bleeding or by the use of suction. Bleeding may be temporarily controlled by introducing a finger into the foramen of Winslow and grasping the hepatic artery. Injury to the liver when removing the gallbladder results in excessive bleeding, bile leakage and postoperative reaction by destruction of liver cells.

Opening the common duct may result in *stricture* if the duct is torn or reduced in caliber by careless suturing. A common cause of stricture is injury to the ducts during operation.

To avoid leaving stones in the common duct, *it must be carefully and gently searched* with probe, scoop and forceps. Irrigation with saline solution may aid in removing small stones and gravel and in testing the patency of the ampulla of Vater. When the common duct is explored, it may be punctured by making rough attempts to pass a stiff metal probe through the ampulla into the duodenum. After prolonged and complete obstruction of the common duct, intermittent drainage by clamping the tube, or back-pressure drainage by elevating the tube, as suggested by Ravdin and Frazier, is safer than sudden decompression of the liver.

Leakage of bile during the operation should be avoided as much as possible. In the event leakage occurs, bile is readily and completely removed by suction. Bile should not be left free in the peritoneal cavity. If the bile is infected, peritonitis may result, and in any event the irritating effect of bile in the peritoneal cavity results in the excessive formation of adhesions.

CHOLECYSTOSTOMY

Technique (Fig. 431)

Cholecystostomy may be indicated in the patient with acute cholecystitis who, because of age or intercurrent disease, is not considered a suitable risk for cholecystectomy.

The head of the operating table may be raised so that the abdominal contents will tend to gravitate downward. Many incisions have been used to expose the gallbladder and ducts. The right paramedian or transverse incision is adequate.

If adhesions are present, the gallbladder and liver margin are carefully freed by blunt and sharp dissection, using care not to injure the colon or duodenum. The fundus of the gallbladder is then grasped with two Allis forceps and an incision made about 1 cm. long in the fundus, a sufficient distance from the liver margin to permit easy closure with a purse-string suture. If the gallbladder is much distended or acutely inflamed, it is wise to aspirate its contents with a trocar before making the incision. Infected gallbladder contents must not be spilled into the peritoneal cavity. The wound can be kept free of exudate and blood by the constant use of suction. The gallbladder is explored with a small scoop and all stones removed. After the gallbladder

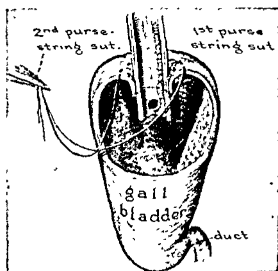


FIGURE 431 Technique of cholecystostomy. The fundus of the gallbladder is inverted about a rubber tube with 2 purse-string sutures (Babcock· Textbook of Surgery)

has collapsed, the cystic duct should be carefully palpated for the presence of stones. The common duct should also be palpated when possible. A free flow of yellow bile from the gallbladder indicates patency of the cystic duct.

A rubber tube approximately 1 cm. in diameter with one or two lateral openings may be used for drainage. The tube is inserted well into the body of the gallbladder. A purse-string suture is placed through the gallbladder wall about the opening and closed around the tube. The suture is passed through the wall of the tube and tied, or the margin of the wound may be fixed to the tube by a single suture. A second purse-string suture is placed about 0.5 cm. from the first suture and the margin of the wound inverted when it is tied. This makes a firm closure about the rubber tube that will prevent leakage. Fine chromic catgut is satisfactory for suture material. When possible, the tube should be passed through the omentum and attached to the abdominal wall. The tube may emerge from the upper end of the incision or be passed through a stab wound made to the right of the incision. If there has been much soiling of the peritoneum, a rubber tissue drain should be placed below the gallbladder, to be removed in two or three days. The gallbladder drainage tube will usually loosen sufficiently to be removed in ten to twelve days.

CHOLECYSTECTOMY

Technique (Figs. 432, 433, 434)

An incision is made as for cholecystostomy. If operative cholangiography is anticipated, wound towels should be sewed in place rather than clamped on with towel clamps. The abdomen is explored, and the condition of the pelvic organs; spleen, kidneys, liver, pancreas, stomach and duodenum is carefully noted. The fundus of the gallbladder is identified and grasped with a curved clamp. If the gallbladder is large and tightly distended, it should first be aspirated with a trocar and suction. At

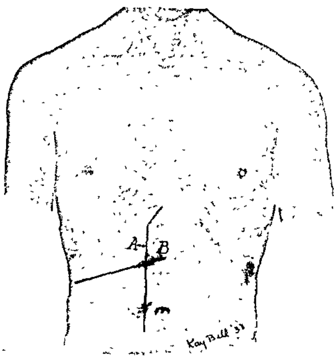


FIGURE 432 Incisions most frequently used for gall tract operations *A*, Vertical right upper rectus incision. This may be continued through the fibers of the rectus muscle, or the muscle may be retracted laterally. *B*, Transverse incision of Singleton (see Chap 12)



FIGURE 433 Technique of cholecystectomy. *A*, Common duct, common hepatic duct and cystic duct exposed. Gallbladder used for traction while ligature is passed about cystic duct *B*, Cystic duct ligated and divided. Ligature being passed beneath cystic artery.

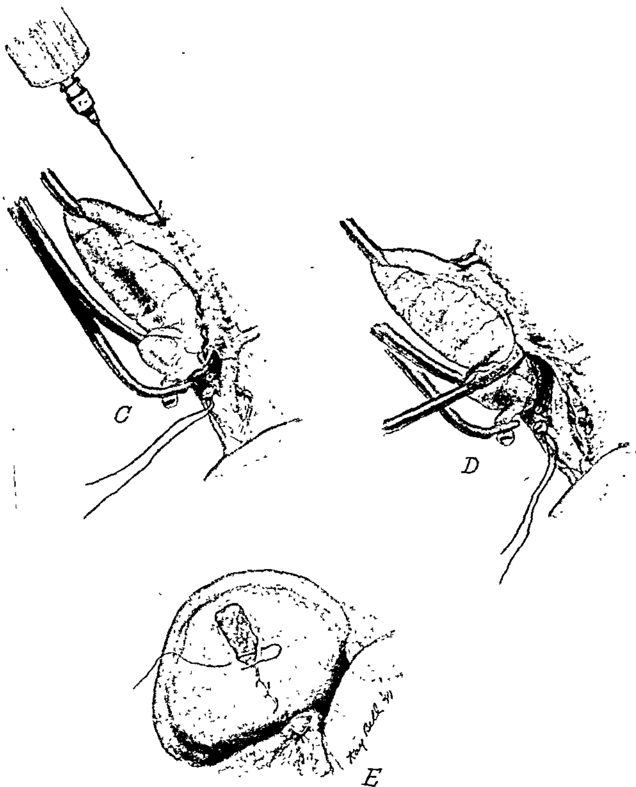


FIGURE 434. Technique of cholecystectomy (*continued*) *C*, Cystic duct and cystic artery ligated separately Salt solution injected beneath serosa of gallbladder to aid excision *D*, Curved knife may be used to incise serosa about gallbladder. *E*, Gallbladder bed sutured Omentum sutured to stump of cystic duct.

this point it is wise to explore the gallbladder, gall ducts and surrounding structures by palpation and inspection. The gallbladder and liver margin are lifted as far as possible through the wound and a second curved clamp applied to the wall of the gallbladder near the cystic duct. The hepatoduodenal ligament and gastrohepatic omentum are identified. While making traction on the gallbladder, gauze packs moistened with physiologic sodium chloride solution are placed to separate the colon, duodenum and stomach from the operative field. These structures are retracted away from the operative field by the hand of an assistant or by wide-bladed retractors.

Dissection is begun with scissors over the cystic duct and continued downward, exposing the cystic, common hepatic and common ducts. Nothing should be severed or incised until accurately identified. The cystic duct and cystic artery are dissected free while held taut by traction on the gallbladder. A ligature of medium chromic catgut or silk is passed about the cystic duct and tied, leaving the ends of the ligature long for future use. To prevent slipping, the duct may be transfixed with the ligature proximal to the point of ligation. The ligation should be made near the common duct, but should not impinge upon its lumen. The cystic duct is clamped at its junction with the gallbladder and severed between the clamp and ligature. The cystic artery is next ligated and severed near the gallbladder. By making slight traction on the fundus and severed cystic duct by the attached clamp, the gallbladder can be dissected from its bed with scissors or curved knife. A margin of peritoneum is left on each side of the gallbladder to facilitate closure of the gallbladder bed. Dissection may be made easier by injecting air or saline solution beneath the peritoneum at its junction with the liver. Any bleeding points or severed accessory bile ducts are ligated. The gallbladder bed is sutured with fine chromic catgut. When possible, the peritoneum is closed over the ducts to minimize adhesions.

Drainage is advisable in most cases. A rubber tissue or cigarette type of drain should be placed along the gallbladder bed to Morison's space, but not in contact with the ducts. It may emerge through the wound or through a stab wound near the rib margin external to the rectus muscle. (Abdominal wound closure is described in Chapter 12.)

CHOLEDOCHOTOMY AND CHOLEDOCHOSTOMY

Technique (Fig. 435)

The exposure of the gallbladder and bile ducts is made as described for cholecystostomy. Accurate visualization of the ducts is imperative for successful exploration and removal of stones. In a high percentage of cases the gallbladder should be removed when the common or hepatic ducts contain stones. Before any extensive dissection is made, the bile ducts and head of the pancreas should be explored by palpation, aided by one or two fingers in the foramen of Winslow. Stones in the duct must be distinguished from nearby enlarged lymph nodes and pancreatic tissue.

Roentgenologic visualization of the biliary tree after the instillation of an opaque dye may be of considerable aid. This may be done either before or after exploration of the common duct, or in certain cases several cholangiograms may be indicated during the operation.

The liver margin is lifted upward into the wound. Gauze packs moistened with salt solution are placed so that the stomach and colon are excluded from the field. To expose the common duct, the assistant's hand is the best type of retractor. The fingers are so placed that they straddle the common duct area, exposing the margin of the hepatoduodenal ligament in which lie the common duct, portal vein and hepatic artery. A wide Deaver retractor is satisfactory for displacing the liver margin, round ligament and stomach upward and to the left.

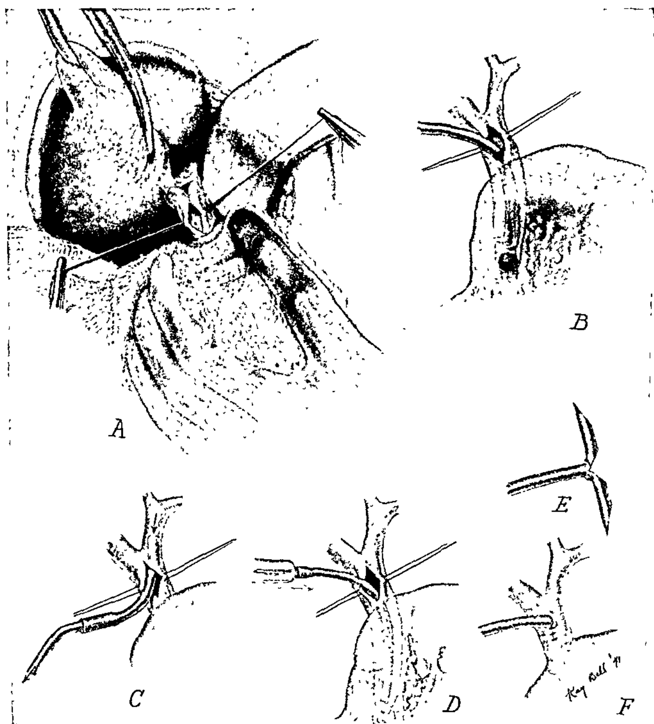


FIGURE 435. Technique of choledochostomy. *A*, Common duct, common hepatic duct and cystic duct exposed. Incision in common duct made between traction sutures. *B*, Exploration of common duct with flexible scoop. *C*, Suction applied through opening in common duct *D*, Irrigation of common duct to wash out gravel and test patency at ampulla. *E*, T-tube cut and notched to facilitate introduction and removal. *F*, Common duct sutured about T-tube.



FIGURE 436. Mobilization of duodenum to expose head of pancreas and retroduodenal portion of common bile duct

With scissors or knife an incision is made in the hepatoduodenal ligament, beginning near the cystic duct. Blunt and sharp dissection with scissors or a small portion of gauze or dental cotton in a clamp will expose the cystic, hepatic and common ducts. If there are any vessels on the surface of the ducts which may be injured when the duct is incised, they should be divided and ligated to maintain a clear operative field. Positive identification of the common duct may be made by aspirating bile with a syringe and small needle. A suction tip should be held in readiness to remove all blood and bile when the common duct is opened. Two traction sutures of fine chromic catgut or silk are placed in the duct.

An incision 1 to 1.5 cm. long is made into the common duct just below its junction with the cystic duct. Stones presenting are removed with forceps. When stones are being removed, the common duct may be lifted and steadied by passing a finger into the foramen of Winslow. Palpable stones above or below the opening can usually be forced to the opening by external manipulation A careful search of the right and left hepatic, common hepatic, cystic and common ducts is made in order with a flexible scoop, curved gallstone forceps, and probe Stones may be felt by using a uterine probe in the ducts as a guide. Suction applied on a small rubber tube introduced in both directions in the duct will remove small stones and gravel and may aid in dislodging large stones. Patency of the ampulla of Vater may be assured by passing a probe or

small dilator into the duodenum. Occasionally this is mechanically impossible wit endangering the duct wall. Patency may also be demonstrated by inse catheter into the common duct down to the ampulla and forcing salt solution thr it into the duodenum with a syringe. The ampulla should not be forcibly dilated

After the common duct has been opened, drainage is indicated. Drainage be done by passing a catheter with side opening upward into the common duct through the incision, by closing the opening in the common duct, and in ing a catheter through the cystic duct stump after removing the gallbladder or b use of a T-tube in the common duct. If a T-tube is used, one should be selected is much smaller than the caliber of the common duct. To facilitate its in and removal, it should be shortened and a section cut from the wall opposite the arm of the T as shown in Figure 435. The tension sutures are removed, and the sion in the duct is closed snugly about the tube with fine chromic catgut att a small curved needle. The sutures should be placed near the margins of the so that there will be no constriction of the duct after closure.

Stones impacted in the retroduodenal portion of the duct or at the ampulla rarely necessitate the mobilization of the duodenum for their removal. This is incising the peritoneum along the second portion of the duodenum, which possible its rotation to the left (Fig. 436). Some bleeding may be encountered this procedure. The duct may be surrounded by pancreatic tissue which bleeds re Location of the stone and fixation of the duct may be aided by a probe passed th the opening in the common duct above the duodenum. After removal of the ste wound in the duct is closed with fine catgut sutures, and all bleeding vessels are

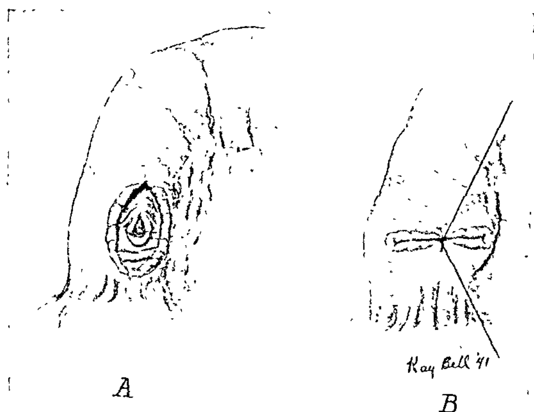


FIGURE 437. Exposure of biliary calculus impacted in the ampulla. *A*, Longitudinal ir been made in the duodenum. Ampulla of Vater has been incised to remove calculus. *B*, O duodenum is closed transversely.



FIGURE 436. *Mobilization of duodenum to expose head of pancreas and retroduodenal portion of common bile duct.*

With scissors or knife an incision is made in the hepatoduodenal ligament, beginning near the cystic duct. Blunt and sharp dissection with scissors or a small portion of gauze or dental cotton in a clamp will expose the cystic, hepatic and common ducts. If there are any vessels on the surface of the ducts which may be injured when the duct is incised, they should be divided and ligated to maintain a clear operative field. Positive identification of the common duct may be made by aspirating bile with a syringe and small needle. A suction tip should be held in readiness to remove all blood and bile when the common duct is opened. Two traction sutures of fine chromic catgut or silk are placed in the duct.

An incision 1 to 1.5 cm. long is made into the common duct just below its junction with the cystic duct. Stones presenting are removed with forceps. When stones are being removed, the common duct may be lifted and steadied by passing a finger into the foramen of Winslow. Palpable stones above or below the opening can usually be forced to the opening by external manipulation. A careful search of the right and left hepatic, common hepatic, cystic and common ducts is made in order with a flexible scoop, curved gallstone forceps, and probe Stones may be felt by using a uterine probe in the ducts as a guide. Suction applied on a small rubber tube introduced in both directions in the duct will remove small stones and gravel and may aid in dislodging large stones. Patency of the ampulla of Vater may be assured by passing a probe or

small dilator into the duodenum. Occasionally this is mechanically impossible without endangering the duct wall. Patency may also be demonstrated by introducing a catheter into the common duct down to the ampulla and forcing salt solution through it into the duodenum with a syringe. The ampulla should not be forcibly dilated.

After the common duct has been opened, drainage is indicated. Drainage may be done by passing a catheter with side opening upward into the common hepatic duct through the incision, by closing the opening in the common duct, and introducing a catheter through the cystic duct stump after removing the gallbladder or by the use of a T-tube in the common duct. If a T-tube is used, one should be selected which is much smaller than the caliber of the common duct. To facilitate its introduction and removal, it should be shortened and a section cut from the wall opposite the long arm of the T as shown in Figure 435. The tension sutures are removed, and the incision in the duct is closed snugly about the tube with fine chromic catgut attached to a small curved needle. The sutures should be placed near the margins of the incision so that there will be no constriction of the duct after closure.

Stones impacted in the retroduodenal portion of the duct or at the ampulla may rarely necessitate the mobilization of the duodenum for their removal. This is done by incising the peritoneum along the second portion of the duodenum, which makes possible its rotation to the left (Fig. 436). Some bleeding may be encountered with this procedure. The duct may be surrounded by pancreatic tissue which bleeds readily. Location of the stone and fixation of the duct may be aided by a probe passed through the opening in the common duct above the duodenum. After removal of the stone the wound in the duct is closed with fine catgut sutures, and all bleeding vessels are care-

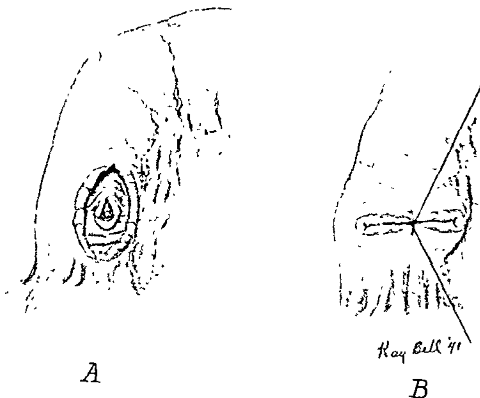


FIGURE 437 Exposure of biliary calculus impacted in the ampulla A, Longitudinal incision has been made in the duodenum Ampulla of Vater has been incised to remove calculus B, Opening in duodenum is closed transversely.



FIGURE 436 Mobilization of duodenum to expose head of pancreas and retroduodenal portion of common bile duct.

With scissors or knife an incision is made in the hepatoduodenal ligament, beginning near the cystic duct. Blunt and sharp dissection with scissors or a small portion of gauze or dental cotton in a clamp will expose the cystic, hepatic and common ducts. If there are any vessels on the surface of the ducts which may be injured when the duct is incised, they should be divided and ligated to maintain a clear operative field. Positive identification of the common duct may be made by aspirating bile with a syringe and small needle. A suction tip should be held in readiness to remove all blood and bile when the common duct is opened. Two traction sutures of fine chromic catgut or silk are placed in the duct.

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After the common duct has been opened, drainage is indicated. Drainage may be done by passing a catheter with side opening upward into the common hepatic duct through the incision, by closing the opening in the common duct, and introducing a catheter through the cystic duct stump after removing the gallbladder or by the use of a T-tube in the common duct. If a T-tube is used, one should be selected which is much smaller than the caliber of the common duct. To facilitate its introduction and removal, it should be shortened and a section cut from the wall opposite the long arm of the T as shown in Figure 435. The tension sutures are removed, and the incision in the duct is closed snugly about the tube with fine chromic catgut attached to a small curved needle. The sutures should be placed near the margins of the incision so that there will be no constriction of the duct after closure.

Stones impacted in the retroduodenal portion of the duct or at the ampulla may rarely necessitate the mobilization of the duodenum for their removal. This is done by incising the peritoneum along the second portion of the duodenum, which makes possible its rotation to the left (Fig. 436). Some bleeding may be encountered with this procedure. The duct may be surrounded by pancreatic tissue which bleeds readily. Location of the stone and fixation of the duct may be aided by a probe passed through the opening in the common duct above the duodenum. After removal of the stone the wound in the duct is closed with fine catgut sutures, and all bleeding vessels are care-

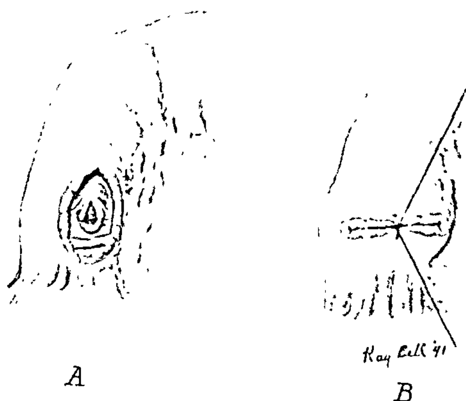


FIGURE 437 Exposure of biliary calculus impacted in the ampulla. *A*, Longitudinal incision has been made in the duodenum. Ampulla of Vater has been incised to remove calculus. *B*, Opening in duodenum is closed transversely.

fully ligated. A soft rubber tissue drain should be placed behind the duodenum. Duct drainage should be made through a supraduodenal opening.

An impacted stone at the ampulla may be approached through the duodenum (Fig. 437). The danger of peritonitis is increased by this procedure, which should not be used except in rare instances when other methods seem impracticable. A longitudinal incision is made in the duodenum over the ampulla about 3 cm. long. The stone is located, and an incision is made in the ampulla over the stone just large enough to permit its extraction. The wound in the ampulla may be left without suture. Closure of the duodenum is made transversely to avoid constriction. Fine chromic catgut placed as a continuous lock suture is used to close the wound margins. This is reinforced with interrupted sutures of silk. The omentum is fixed to the suture line with interrupted stitches. A T-tube drain is placed in the common duct above the duodenum.

The operation is completed by removal of the gallbladder as described above, unless contraindicated by serious duct infection or poor general condition of the patient. The common duct drainage tube is passed through the omentum, which is fixed by suture to the stump of the cystic duct. A Penrose or cigarette type of drain is placed in Morison's space with its lower end below, but not in contact with, the ducts. The wound is closed as in cholecystectomy. The T-tube is fixed to the skin with a fine silk suture. There should be some slack in the tube so that abdominal distention will not cause its premature withdrawal from the common duct. If there is no evidence of infection or persistent drainage of bile, the abdominal drain should be removed in three to five days. When the T-tube is removed on the eighth to the twelfth postoperative day, the T end may be removed and the tube reinserted along its tract to within 2 to 3 cm. of the common duct for twenty-four to forty-eight hours to prevent puddling of bile.

CHOLECYSTOGASTROSTOMY AND CHOLECYSTODUODENOSTOMY

General Considerations

From the standpoint of function there seems to be little difference between an anastomosis between the gallbladder and stomach and between the gallbladder and duodenum It is, therefore, best judgment to make the choice between the two depend upon their anatomical relationship. The procedure should be chosen which will cause the least tension on the suture line. The technique is the same for either anastomosis.

Technique (Fig. 438)

The content of the gallbladder is first aspirated with trocar and suction. The size of the anastomotic opening should be 1.5 to 2 cm. in length. The limits of the incisions to be made in the fundus of the gallbladder and duodenum (or stomach) should be marked by tension sutures or Allis clamps. The fundus of the gallbladder is then sutured to the duodenum (or stomach) with continuous or interrupted sutures of fine silk. Rubber-shod clamps may be placed to avoid peritoneal soiling, although this is not necessary if suction is available

Leaving about 0.5 cm. margin for mucosal suturing, parallel incisions are made

in the gallbladder and duodenum (or stomach). The posterior wound margins are approximated with a continuous through-and-through lock-stitch, and the anterior margins with a Connell stitch using fine chromic catgut. The anterior serosal surfaces are then approximated with continuous or interrupted sutures of silk. A small portion of the gastrocolic or great omentum is used to cover the suture line. The abdomen is closed without drainage.

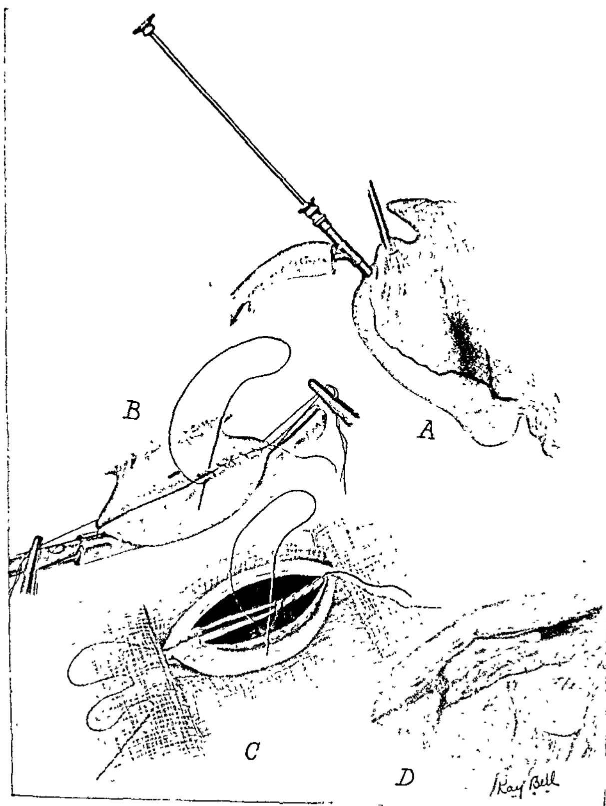


FIGURE 438 Technique of cholecystoduodenostomy *A*, Gallbladder aspirated with trocar and suction. *B*, First row of sutures between gallbladder and duodenum *C*, Gallbladder and duodenum opened. Second row of lock-stitch sutures. *D*, Anastomosis completed and reinforced with omentum.

CHOLEDOCHODUODENOSTOMY

General Considerations

Choledochoduodenostomy is indicated for strictures of the lower end of the common duct due to either benign or malignant disease, when a by-passing operation is the treatment of choice. Anastomosis between the common duct and duodenum is more physiologic than cholecystoduodenostomy and ensures better drainage of the biliary system.

Technique (Fig. 439)

The second portion of the duodenum is mobilized to expose the lower end of the common duct and to reduce tension on the suture line. The common duct is usually dilated when an obstruction exists at its distal end. The duct is freed of overlying tissue distal to its union with the cystic duct.

The lower end of the common duct is sutured to the duodenum with interrupted sutures of fine silk. The end sutures are left long for traction. The anastomotic stoma should be made at least as long as the diameter of the duct. The duct and duodenum are incised about 1 mm. from the suture line, and the wound margins are united with fine chromic catgut. The anastomosis is completed with a row of interrupted silk sutures.



FIGURE 439 Technique of choledochoduodenostomy. The dilated common duct is anastomosed to the duodenum with outer rows of interrupted silk sutures and inner rows of fine chromic catgut sutures The duodenum should not be angulated, and the anastomosis should not be made under tension. The end sutures are left long and used for traction until the anastomosis is completed (Sanders: Ann Surg, Vol. 123, J B Lippincott Company)

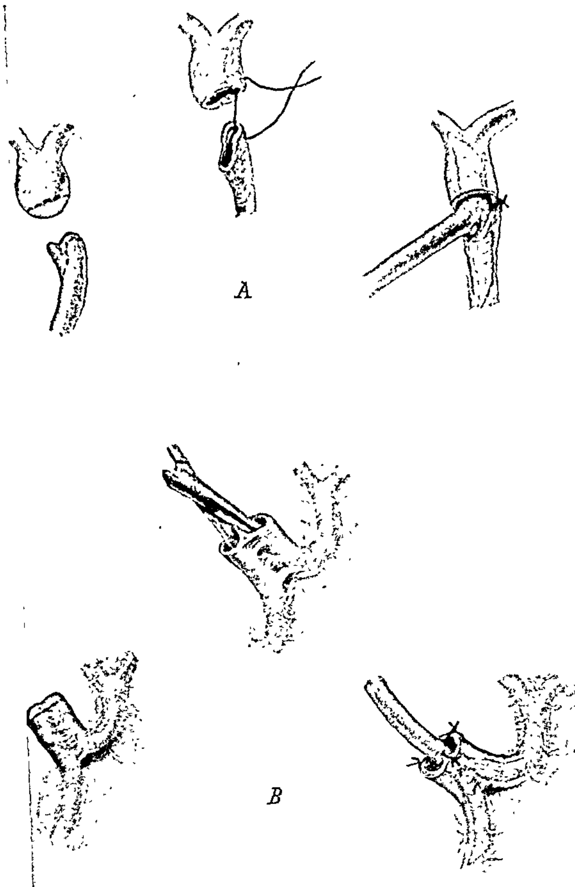


FIGURE 440. Methods of repair of strictures and defects in the extrahepatic ducts *A*, End-to-end suture between common hepatic and common bile ducts *B*, *Severed end of* common hepatic duct adherent to severed end of common bile duct Walls of ducts cut through as in Mikulicz anastomosis A T-tube is inserted into ends of both ducts and the ducts sutured *about the tube.*

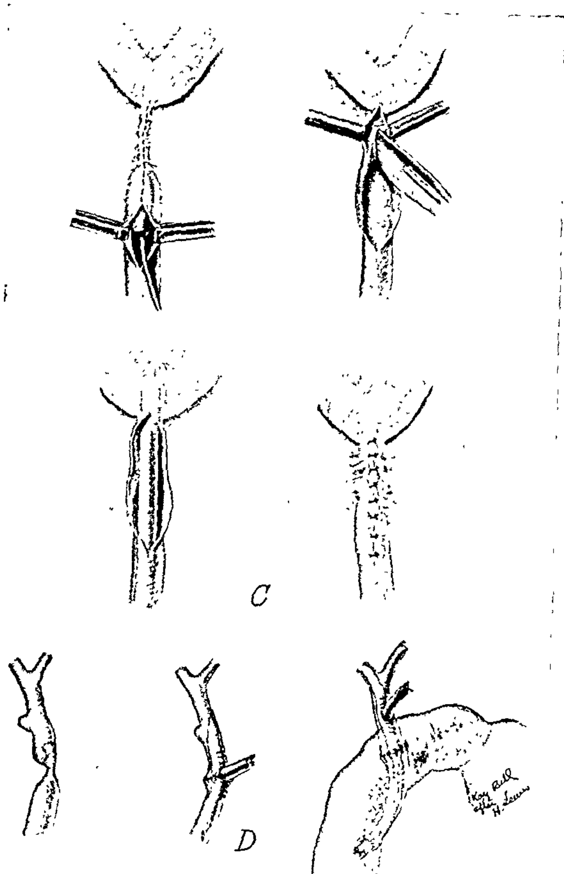


FIGURE 441 Methods of repair of strictures and defects in the extrahepatic ducts (*continued*). *C*, Stricture of common hepatic duct incised and reconstructed over a rubber tube. *D*, Stricture of common duct incised and sutured transversely over a T-tube T-tube may extend into the duodenum (Redrawn from Lahey Ann Surg)

OPERATIONS FOR STRICTURE OF THE BILE DUCTS

Technique

There is no standard operative procedure suitable for all types of stricture of the extrahepatic ducts. Each patient presents an individual problem, the solving of which will depend upon the operative skill and ingenuity of the surgeon.

Simple strictures of the common duct may be successfully treated by anastomosing the gallbladder to the duodenum or stomach (see Cholecystogastrostomy). When the gallbladder has been removed, some type of plastic repair of the ducts or anasto-

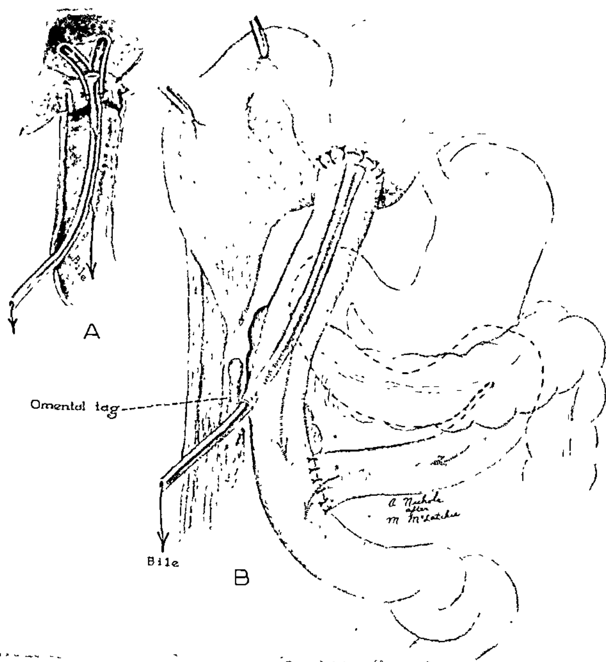


FIGURE 442. Technique of surgical treatment of stricture of bile duct *A*, Rubber tube sutured in blind end of common hepatic duct passes through wall of jejunum Open end of jejunum has been sutured to scar tissue in liver sulcus Opening in tube for bile drainage into the jejunum. *B*, Completed operation showing position of rubber tube and jejunojejunostomy. The rubber tube is passed through an omental tab and through a stab wound in the abdominal wall lateral to the primary abdominal incision (Redrawn from Allen Ann Surg , Vol. 121)

mosis between the ducts and the duodenum or stomach is necessary. In an occasional case when all other methods seem impractical, a fistulous tract leading from the gall duct to the skin may be dissected free and implanted into the stomach or duodenum. The reported results of this operation have not been very satisfactory, and it should be avoided when possible.

The preliminary steps in the operation for stricture of the bile ducts involve a careful dissection for the exposure of the ducts and identification of neighboring anatomical structures. Subsequent steps must depend upon the pathologic condition found and the available tissue with which to reconstruct the ducts. Figures 440 and 441 illustrate several methods used by Lahey.

For extensive strictures with only a short segment of common hepatic duct remaining, Allen (Fig. 442) *has recommended anastomosis of the liver about the remaining ducts to the cut end of the jejunum, using the Roux-Y principle.* A rubber catheter is used in the duct or lumen of the jejunum and is brought through the wall of the jejunum and abdominal wall.

For cases in which biliary-enteric continuity cannot be re-established by the method described, Longmire has recommended resection of a portion of the left lobe of the liver and anastomosis between a major hepatic duct and the jejunum in a *Roux-Y fashion.*

OPERATIONS FOR CONGENITAL ATRESIA OF BILE DUCTS

General Considerations

Any portion or all of the gallbladder and extrabiliary passages may be partially *or completely obliterated. In a series of forty-five cases* Ladd found forty with complete

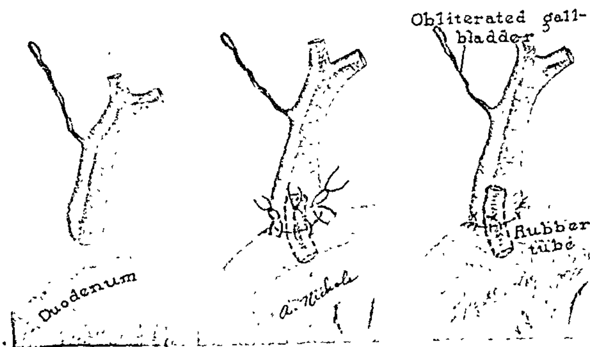


FIGURE 443 Technique of anastomosis of the common duct to the duodenum for congenital atresia of the bile duct An end-to-side anastomosis is made over a small rubber tube, using a single row of interrupted mattress sutures of fine silk (Redrawn from Ladd Ann. Surg, Vol 102)

obstruction. There were possibilities of cure in 37 per cent and recoveries in 60 per cent of the operable cases with complete obstruction. Exploration is indicated in all cases.

Technique of Operation

A right rectus incision is commonly used. Exploration is difficult because of the small size of the patient and organs. If the gallbladder is patent, it may be opened and saline solution injected to aid in the identification of the ducts. If no ducts can be identified, the condition is considered inoperable. If the gallbladder and common hepatic duct are patent, the gallbladder may be anastomosed to the stomach or duodenum. An obstructed common hepatic or common bile duct should be anastomosed to the duodenum. This is often a difficult technical procedure. Anastomosis may be made over a small rubber tube, using one row of fine silk mattress sutures, as suggested by Ladd (Fig. 443).

Operations upon the Pancreas

Anatomy

The pancreas is a deeply placed retroperitoneal organ which extends from the curve of the duodenum to the left across the twelfth thoracic and first lumbar vertebrae to the hilum of the spleen. For purposes of description it is divided into the head, neck, body and tail. The head lies in the curve of the duodenum, and frequently a portion surrounds the common bile duct above the ampulla of Vater. The main pancreatic duct (Wirsung) joins the common duct at the ampulla of Vater where both enter the duodenum. In a small percentage of cases an accessory duct (Santorini), draining a portion of the head of the pancreas, enters the duodenum proximal to the papilla of Vater.

The pylorus and transverse colon lie anterior to the head and the vena cava posterior. The neck is short and related anteriorly to the pylorus and posteriorly to the common duct, portal vein, hepatic artery and the junction of the splenic artery and veins.

The body of the pancreas extends from the vertebrae to the left to end in the short tail. It is somewhat triangular in cross section and presents three surfaces. The anterior surface is covered with peritoneum. The inferior surface overlies the splenic vein and left renal vessels. The upper surface is grooved by the splenic artery.

The tail ends in the lienorenal ligament. The colic flexure lies below. When long, the tail may reach the hilum of the spleen and be surrounded by splenic vessels.

ACUTE PANCREATITIS

General Considerations

Acute pancreatitis is a serious disease with a significant mortality regardless of the plan of treatment. At one time early operation with drainage was advocated by most surgeons. At present, conservative nonoperative treatment is recommended in the acute stage of the disease. There is such a wide variation in the extent and severity of

acute infections of the pancreas that statistical reports of small groups may be misleading. Proper supportive treatment is imperative. In the presence of abscess formation following acute pancreatitis operation for the purpose of establishing drainage may be indicated.

Technique of Operation

A left rectus or upper abdominal transverse incision is made. The pancreas may be approached through either the gastrohepatic or gastrocolic omentum, preferably the latter. Fat necrosis will usually be noted in the omentum or mesentery. Before incising the pancreas, the abdominal cavity should be well protected with gauze packs. Suction should be used to remove serous exudate, blood, necrotic material, and pus. The capsule of the pancreas is opened, necrotic tissue is removed, and the involved area adequately drained with gauze and rubber tissue. Sloughing may occur which may prolong drainage for weeks or even months, causing excoriation of the skin. Postoperative hernia is not infrequent.

Whipple advises that the pancreas be inspected and the area of greatest involvement and the lesser peritoneal cavity be drained with cigarette drains without incising the pancreas. If the lower peritoneal attachment of the pancreas can be freed by blunt dissection, this step may be added to relieve tension.

In the subacute types of pancreatitis with gangrene or suppuration, drainage is indicated. In such cases the viscera must be carefully protected from contamination as the operation progresses. Drainage may be through the abdominal wound or through a lumbar incision. For well developed abscesses direct drainage through the lumbar route is indicated without opening the abdomen for exploration.

Biliary tract disease is so frequently associated with acute pancreatic disease that exploration and drainage of the gallbladder or common duct may be indicated if the condition of the patient permits. The hazard is frequently so great that drainage of the gall tract should be postponed.

CHRONIC PANCREATITIS

General Considerations

The management of chronic relapsing pancreatitis by operative means remains one of the unanswered problems in surgery. Several different operative procedures have been devised with only moderate success when evaluated over a long-term follow-up period. Since infection in the gallbladder frequently is associated with chronic pancreatitis, careful study of the biliary tract should be carried out, and in the presence of gallbladder disease cholecystectomy and drainage of the common duct should be done. Section of the sphincter of Oddi as devised by Doubilet and Mulholland to overcome possible biliary obstruction and prevent the reflux of bile into the pancreatic duct has produced favorable results in a fairly large series of cases. DuVal and others have advocated the use of caudal pancreaticojejunostomy—that is, amputation of the tail of the pancreas and anastomosis of the tail of the pancreas and pancreatic duct to a Roux-Y arm of jejunum—as the method of choice when there is obstruction or dilatation of the pancreatic duct In certain cases in which the intractable pain often observed in this condition cannot be relieved by other means, the use of dorsal

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sympathectomy and splanchnicectomy may give dramatic relief from pain. This procedure, of course, has no effect on the primary disease. The early enthusiasm for this procedure has diminished considerably because of the high incidence of recurrence of pain in a few months or years following operation. Total pancreatectomy may be necessary in a small number of cases which have not responded to other therapeutic measures.

Choledochal Sphincterotomy (Fig. 444)

This operation is based on the hypothesis that the retrograde passage of bile into the pancreatic duct from the common channel of the bile duct and pancreatic duct is the underlying cause of relapsing pancreatitis. Doubilet and Mulholland have accumulated a large series of cases in which this procedure has been done with favorable results and have studied extensively the anatomy and physiology of this region both clinically and in the laboratories. They have developed several special instruments to facilitate the operation. The exact technique of sphincterotomy varies considerably, depending upon the operative findings. The sphincter can be divided endocholedochally by passing a special sphincterotome into the common duct and down to the region of the sphincter, or the ampulla of Vater can be exposed directly by opening the anterior wall of the duodenum. This technique is preferred. In most cases roentgenographic visualization of the biliary and pancreatic ducts after the injection of radiopaque dye is indicated. When sphincterotomy is carried out, the gallbladder should always be removed even though it may appear to be normal, since the function of the gallbladder is usually disturbed after sphincterotomy with resultant stasis and infection.

Preoperative medication should not include morphine, since this drug tends to produce spasm of the sphincter. In addition, atropine should be used only in small doses.

Operative exposure can best be obtained by using an adequate transverse incision. In most instances the gastrohepatic omentum will be contracted and fibrosed, owing to the previous attacks of pancreatitis; therefore the lateral peritoneal reflection of the duodenum should be incised, permitting the duodenum to be retracted downward and medially. This also permits straightening of the common duct. If the gallbladder is present, the cystic duct is isolated and a catheter passed through a hole in the cystic duct into the common duct for injection of the radiopaque dye. If the gallbladder has been removed, it is usually necessary to make a small opening in the common bile duct proper for insertion of the catheter In order to obtain spasm of the sphincter of Oddi, 30 cc of tenth-normal hydrochloric acid are injected through a nasogastric tube, the end of which lies in the duodenum. After this, 70 per cent Urokon is injected into the common duct under slight pressure and the roentgenogram taken. In this fashion the pancreatic and common bile ducts can be visualized. A probe is then passed down the common duct to the region of the ampulla. When the end of the probe can be seen or palpated against the anterior duodenal wall, a 1.5-cm. incision is made in the anterior wall of the duodenum close to the medial border and in line with its axis

Doubilet has developed a special balloon catheter which can be used for this purpose. When the papilla has been exposed, three traction sutures are placed. These

sutures must include muscularis, since mucosal sutures will tear out and result in bleeding. With the papilla under control in this fashion, a special retrograde spincterotome is attached to the catheter and advanced into the ampulla. A narrow section of the anterior wall of the ampulla for a distance of 8 to 10 mm. is then punched out with the sphincterotome. In place of the special sphincterotome, a small straight mosquito clamp can be used, passing one jaw of the clamp into the ampulla for a distance of 10 mm. and closing the clamp. The tissue held by this clamp can then be excised with a knife. When the sphincter has been divided, the opening of the duct of Wirsung may be visualized and further roentgenologic visualization of the pancreatic ducts carried out if indicated. If the common duct has been opened for exploration or to aid in the sphincterotomy, a short-arm T-tube is inserted and left in place postoperatively. If the procedure has been done through the stump of the cystic duct, drainage of the biliary tree is not necessary.

Postoperatively, the pancreas and liver should be put at rest and the secretion

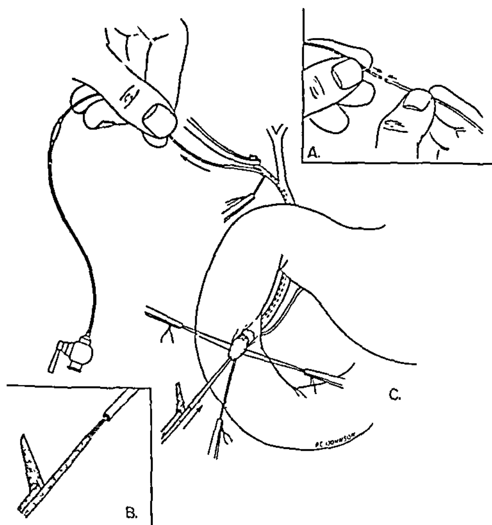


FIGURE 444. Technique of section of the sphincter of Oddi. The special balloon catheter shown in *C* has been passed into the cystic duct and down the common bile duct to permit exposure of the ampulla through a small opening in the anterior wall of the duodenum and the placing of traction sutures from the ampulla. A plastic tube is then attached to the distal end of the special balloon catheter, as illustrated in *A*, and drawn in a retrograde fashion through the ampulla and out of the opening in the cystic duct. The special retrograde sphincterotome is then attached to the end of the plastic tube, as illustrated in *B*, and drawn up into the ampulla. On closure of the sphincterotome the superior portion of the sphincter is cut for a distance of 10 mm (H. Doubilet. S Clin. North America, Vol. 36.)

of pancreatic juice stopped. This can be accomplished by the use of nasogastric suction postoperatively and the use of anticholinergic drugs such as atropine, Banthine or Pamine.

Nasogastric suction should be continued for three days, after which fat-free, clear liquids can be given. Fats and alcohol should be excluded from the diet postoperatively.

Caudal Pancreaticojejunostomy (DuVal) (Figs. 445 to 449)

This procedure is designed to relieve obstruction of the pancreatic duct by rerouting pancreatic secretions into the jejunum by way of the tail of the pancreas. The presence of obstruction of the pancreatic duct may be suspected by means of the secretin test; in most instances, however, exploration of the duct is necessary.

The abdomen is opened through a left rectus or left subcostal incision. After exploration of the abdomen the gastrocolic omentum is divided between clamps to permit exposure of the tail of the pancreas through the lesser sac. The peritoneum over the superior and inferior margins of the pancreas is incised, taking care that the inferior incision is to the left of the superior mesenteric vein. By using blunt finger dissection behind the pancreas, the pancreas is elevated and encircled with a soft rubber catheter. Care must be taken to avoid injury to the splenic vein. Traction is maintained on the catheter, and the pancreas is transected from front to back slowly in an effort to identify and isolate the pancreatic duct before incising it. A duct larger than 2 mm. in cross-section diameter at this level indicates obstruction, and the decompression operation should be accomplished. A normal-sized duct does not exclude the presence of obstruction. A fine catheter is passed into the duct toward the head of

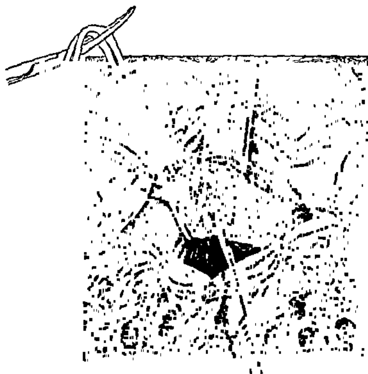


FIGURE 445 Caudal pancreaticojejunostomy. The pancreas has been exposed by dividing the gastrocolic ligament and a rubber catheter passed around the pancreas to elevate the pancreas for better exposure The pancreas has been partially transected to expose the pancreatic duct (M. K. DuVal: S Clin North America, Vol. 36.)

the pancreas and secured with a ligature, and 4 cc. of 70 per cent Diodrast are introduced into the catheter slowly at a pressure not exceeding 25 mm. of mercury. A *roentgenogram is then taken*, and enlargement of the duct or failure to see dye in the duodenum under these conditions is thought to indicate pancreatic duct obstruction.

The spleen and tail of the pancreas are now mobilized by dividing the short gastric vessel and splenocolic ligament. As the tail of the pancreas is dissected posteriorly, care must be taken to avoid injury to the left adrenal gland. The splenic artery and splenic veins are then secured by placing a suture ligature around these vessels as they course through the superior portion of the pancreas. The ligature *should be placed about 1 cm. proximal to the site of contemplated pancreatic division.* A small rent is then made in the transverse mesocolon and the jejunum divided between clamps just distal to the ligament of Treitz. At least 12 inches of the distal jejunum are then pulled through the rent in the transverse mesocolon into the lesser sac. Intestinal continuity is then re-established by an end-to-side anastomosis. The Roux-Y limb is sutured to the rent in the mesocolon to avoid subsequent hernia. The tail of the pancreas and spleen are now removed by completely transecting the pan-



FIGURE 446 Caudal pancreaticojejunostomy (*continued*) A cannula is placed in the pancreatic duct and secured with a suture for roentgenographic visualization of the duct (M K DuVal S Clin North America, Vol. 36)



FIGURE 447 Caudal pancreaticojejunostomy (*continued*) The jejunum is divided between clamps just distal to the ligament of Treitz for preparation of a Roux-Y limb of jejunum (M. K DuVal S Clin North America, Vol 36)

Technique of Roux-Y Pancreatic Cystojejunostomy (Fig. 450)

An upper transverse or paramedian incision is satisfactory. After exploration of the abdomen the cyst is exposed along the presenting surface. In most instances this necessitates division of the gastrocolic omentum. The contents of the cyst are then evacuated by use of a trocar and cannula and the opening enlarged to at least 4 cm in length. The jejunum is then identified and divided between clamps just distal to the ligament of Treitz. The distal cut end of jejunum is then brought up to the opening in the cyst wall either through a rent in the transverse mesocolon or anterior to the transverse colon as indicated by the position of the cyst. An anastomosis is then made between the cut end of jejunum and the opening in the cyst. This anastomosis is carried out in the same fashion as when doing an end-to-end intestinal anastomosis, using an inner layer of chromic catgut reinforced by an outer row of interrupted silk sutures. If the arm of jejunum has been brought up through a rent in the transverse mesocolon, this must be tacked to the jejunal serosa to prevent future herniation through this area. Intestinal continuity is then re-established by making an end-to-side anastomosis of the proximal jejunal segment to the distal jejunal segment at a point 45 cm. below the cystojejunostomy. This long defunctionalized loop of jejunum will prevent the reflex of food into the cyst. The abdomen is then closed in routine fashion.

TUMORS OF THE PANCREAS

General Considerations

Carcinomas of the body of the pancreas are rarely operable when discovered. This is also true of sarcomas. Carcinomas of the head of the pancreas and carcinomas arising in the terminal common bile duct and ampulla of Vater involving the pancreas, manifested clinically by producing obstruction of the common duct, may in selected cases be amenable to excision.

Great advance has been made in recent years in the surgery of the pancreas for the treatment of hyperinsulinism. Either excision of pancreatic adenoma or subtotal pancreatectomy may be indicated for the cure of this condition.

Technique of Subtotal Pancreatectomy (McCaughan) (Fig. 451)

The back is elevated to aid exposure. A long left rectus incision is used. The approach to the pancreas is made through the gastrohepatic or gastrocolic omentum, preferably the latter. The gastrocolic omentum is divided transversely. The stomach is retracted upward and the colon downward. The peritoneum is divided, and the pancreas is dissected free, beginning at the tail. An important step is the retraction of the splenic artery and vein with tape. As the tail is lifted, the small vessels are carefully isolated and ligated. The pancreas is intimately attached to the splenic artery and vein. If either is wounded and hemorrhage becomes a serious problem, they may be ligated and the spleen removed.

One may remove as much of the gland as desired up to 90 per cent without permanent glycosuria The pancreas is severed with a V-shaped incision and sutured securely with fine chromic catgut or silk. Drainage is always necessary.

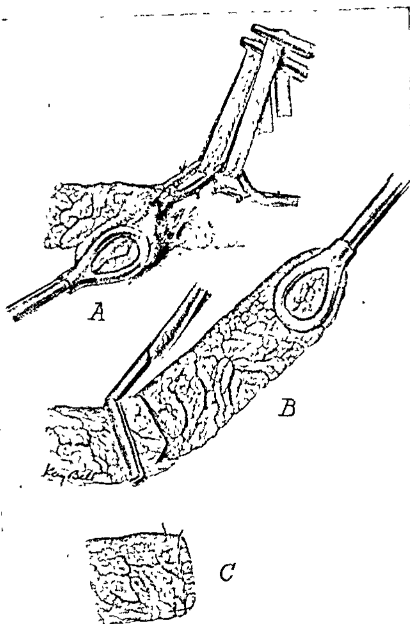


FIGURE 451 Technique of subtotal pancreatectomy. *A*, Large vessels are retracted with tape as the tail and body of the pancreas are lifted with a sponge forceps. This exposes the small vessels, which are clamped and ligated as the dissection proceeds *B*, Body of pancreas grasped with rubber-shod clamp to control bleeding during resection and suture. *C*, Type of sutures used to close severed end of pancreas (Redrawn from McCaughan: Ann. Surg)

Technique of Excision of Adenoma for Hyperinsulinism (Whipple and Frantz) (Fig. 452)

Spinal anesthesia is recommended for good relaxation. A wide transverse incision, including both recti muscles, is made above the umbilicus. The gastrocolic omentum is widely divided to expose the entire pancreas. An adenoma may be identified by palpation or recognized as a purplish-pink nodule usually 1 to 2 cm. in diameter. The adenoma is encapsulated and may be shelled out of the pancreatic tissue. Small vessels present should be ligated with fine ligatures of silk or catgut. Adenomas are often multiple and are usually found in the tail or body. The pancreas is mobilized by incising the inferior peritoneal attachments, and the posterior surface is inspected and palpated. If no adenoma is found in the tail or body, the duodenum

Technique of Roux-Y Pancreatic Cystojejunostomy (Fig. 450)

An upper transverse or paramedian incision is satisfactory. After exploration of the abdomen the cyst is exposed along the presenting surface. In most instances this necessitates division of the gastrocolic omentum. The contents of the cyst are then evacuated by use of a trocar and cannula and the opening enlarged to at least 4 cm in length. The jejunum is then identified and divided between clamps just distal to the ligament of Treitz. The distal cut end of jejunum is then brought up to the opening in the cyst wall either through a rent in the transverse mesocolon or anterior to the transverse colon as indicated by the position of the cyst. An anastomosis is then made between the cut end of jejunum and the opening in the cyst. This anastomosis is carried out in the same fashion as when doing an end-to-end intestinal anastomosis, using an inner layer of chromic catgut reinforced by an outer row of interrupted silk sutures. If the arm of jejunum has been brought up through a rent in the transverse mesocolon, this must be tacked to the jejunal serosa to prevent future herniation through this area. Intestinal continuity is then re-established by making an end-to-side anastomosis of the proximal jejunal segment to the distal jejunal segment at a point 45 cm below the cystojejunostomy. This long defunctionalized loop of jejunum will prevent the reflex of food into the cyst. The abdomen is then closed in routine fashion.

TUMORS OF THE PANCREAS

General Considerations

Carcinomas of the body of the pancreas are rarely operable when discovered. This is also true of sarcomas. Carcinomas of the head of the pancreas and carcinomas arising in the terminal common bile duct and ampulla of Vater involving the pancreas, manifested clinically by producing obstruction of the common duct, may in selected cases be amenable to excision.

Great advance has been made in recent years in the surgery of the pancreas for the treatment of hyperinsulinism. Either excision of pancreatic adenoma or subtotal pancreatectomy may be indicated for the cure of this condition.

Technique of Subtotal Pancreatectomy (McCaughan) (Fig. 451)

The back is elevated to aid exposure. A long left rectus incision is used. The approach to the pancreas is made through the gastrohepatic or gastrocolic omentum, preferably the latter. The gastrocolic omentum is divided transversely. The stomach is retracted upward and the colon downward. The peritoneum is divided, and the pancreas is dissected free, beginning at the tail. An important step is the retraction of the splenic artery and vein with tape. As the tail is lifted, the small vessels are carefully isolated and ligated. The pancreas is intimately attached to the splenic artery and vein. If either is wounded and hemorrhage becomes a serious problem, they may be ligated and the spleen removed.

One may remove as much of the gland as desired up to 90 per cent without permanent glycosuria. The pancreas is severed with a V-shaped incision and sutured securely with fine chromic catgut or silk. Drainage is always necessary.

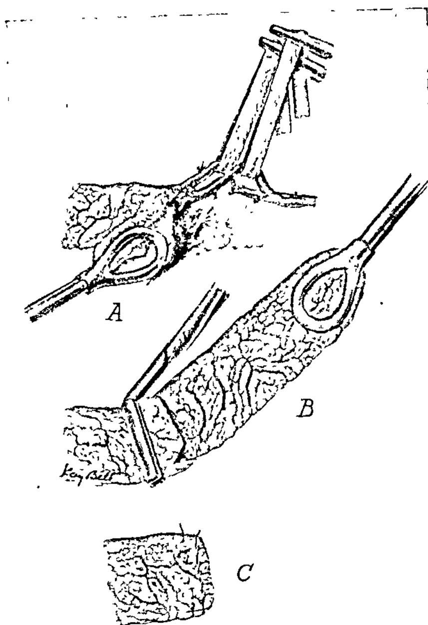


FIGURE 451. Technique of subtotal pancreatectomy. *A*, Large vessels are retracted with tape as the tail and body of the pancreas are lifted with a sponge forceps This exposes the small vessels, which are clamped and ligated as the dissection proceeds. *B*, Body of pancreas grasped with rubber-shod clamp to control bleeding during resection and suture. *C*, Type of sutures used to close severed end of pancreas. (Redrawn from McCaughan: Ann. Surg)

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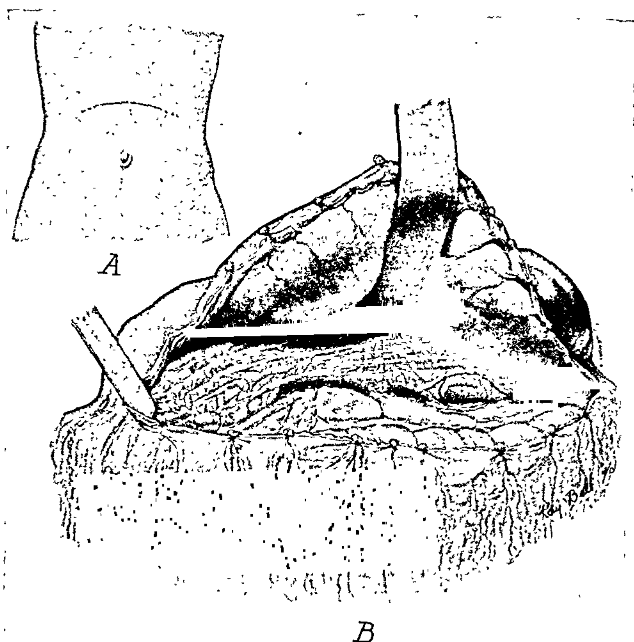


FIGURE 452. Technique of excision of adenoma of the pancreas *A*, Type of transverse abdominal incision used to explore pancreas *B*, Exposure of pancreas by dividing gastrocolic omentum and retracting stomach Adenoma exposed by dividing peritoneum at lower border of pancreas (Redrawn from Whipple and Frantz: Ann Surg)

should be mobilized and the head thoroughly investigated by inspection and palpation. Resection of two thirds of the pancreas is justifiable if no tumor is found. A rubber tissue drain is placed down to the bed of the pancreas to emerge at the outer margin of the left rectus muscle. Careful closure of the fascias and rectus muscles is essential for sound healing.

CARCINOMA OF THE AMPULLA AND HEAD OF PANCREAS

Dangers and Safeguards

Patients with carcinoma involving the lower end of the common duct are usually deeply jaundiced. Deep jaundice may be associated with a marked hemorrhagic

diathesis, liver damage, undernourishment and dehydration. Such patients are poor surgical risks. *Careful preoperative and postoperative treatment is mandatory.* Vitamin K should be given both before and after operation. Two-stage operations may be advisable, although one-stage operations are preferable. If a two-stage procedure is selected, the gallbladder or common duct is anastomosed to the stomach, duodenum or jejunum as the first stage, to re-establish the flow of bile before excision of the tumor is attempted. The second stage may be done after liver function has been restored and the state of nutrition has improved. If metastases are present, it is useless to attempt removal of the primary tumor by a second-stage operation.

Resection of the head of the pancreas and duodenum is an operation of some magnitude, often requiring three to five hours. It may be complicated by hemorrhage and shock. Intravenous fluids and transfusions should be given during the operation and continued after the operation.

Certain fundamental principles should be followed when resecting the head of the pancreas and duodenum. It is somewhat safer to remove the first portion of the jejunum as a part of the bowel resection to avoid damage to the blood supply and necrosis of the fourth portion of the duodenum. A choledochojejunostomy is preferable to a cholecystojejunostomy because it is more physiologic and assures better drainage of bile. Although closure of the severed end of the pancreas is compatible with life, the digestive function will be less disturbed if the pancreas is anastomosed to the jejunum. The principle of placing the gastrojejunostomy distal to the choledochojejunostomy and pancreaticojejunostomy to prevent ascending biliary infection was established by Whipple. In 1942 Dennis emphasized the importance of separating the biliary and gastric anastomoses with a long segment of jejunum (40 cm.) to prevent reflux of the gastric and intestinal contents into the biliary tract. Pearse has also emphasized this point and has suggested that the segment of jejunum proximal to the gastrojejunostomy be at least 8 inches (20 cm.) long.

Complications which may develop after the operation are cholangitis, biliary fistula, pancreatic fistula, and duodenal fistula and infection. Careful attention to operative technique will reduce these complications to a minimum.

Pancreaticoduodenectomy will probably have a mortality rate of 15 to 25 per cent. Life is prolonged by this operation, but final results have not yet been determined.

Technique of Pancreaticoduodenectomy (Fig. 453)

Spinal anesthesia is recommended. This may be supplemented by inhalation anesthesia when necessary.

A right paramedian or transverse abdominal incision is made. After careful exploration and evaluation of the patient's condition the surgeon must make his choice between a one-stage and two-stage operation.

If the two-stage operation is chosen, the gallbladder or common duct is anastomosed to the stomach, duodenum or jejunum. A gastroenterostomy may also be done as recommended by Whipple, Parsons and Mullins in their original description of the operation. When the pancreaticoduodenectomy is done at the second stage of the operation, it will be necessary to detach and reanastomose the gallbladder or common duct to the jejunum. If a gastroenterostomy has been done, the pyloric end of the stomach and distal end of the duodenum are closed and an end-to-side anastomosis made between the proximal and distal segments of the divided jejunum. The

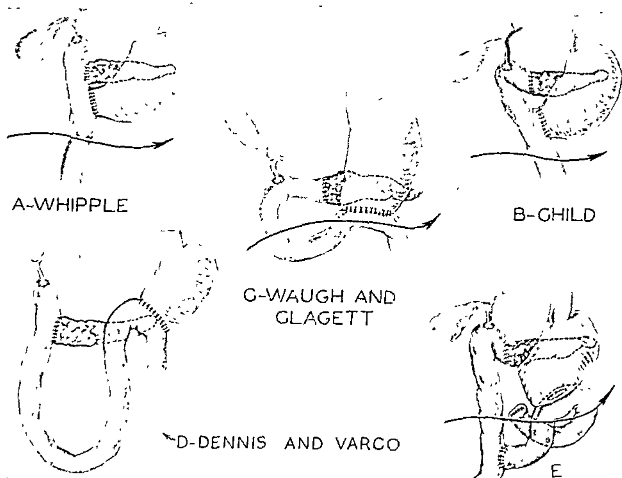


FIGURE 453. Technique of pancreaticoduodenectomy. Sketches of five completed operations. In *A* and *B* the gastrojejunostomy is too near the other anastomoses. In *C* and *D* the gastrojejunostomy is placed 20 to 30 cm. distal to the other two anastomoses to prevent regurgitation of intestinal content into the biliary and pancreatic ducts Technique shown in *E* is suitable for two-stage operation when gastroenterostomy is done in first stage.

open end of the distal segment of the jejunum is used to cap the cut end of the pancreas, and an end-to-side anastomosis is made between the common duct and jejunum. An equally satisfactory procedure is an end-to-end anastomosis between the common duct and jejunum, and an end-to-side anastomosis between the jejunum and the end of the pancreas or pancreatic duct.

The one-stage operation is preferred. The duodenum is first mobilized to permit exploration of the head of the pancreas and to determine the extent of the tumor and the relation of the pancreas to the mesenteric vessels. The hepatoduodenal ligament is next incised, and the lower end of the common duct is separated from the portal vein and divided between clamps. The clamp on the distal segment of the duct is used for traction. The pyloric end of the stomach is freed, and the gastroduodenal artery is identified, divided and ligated. The stomach is divided between Payr clamps through the antrum. By reflecting the cut ends of the stomach, the neck of the pancreas is exposed After dissecting all tissue from the surface of the pancreas and freeing it by blunt dissection from the mesenteric vessels, the neck is divided over a flat instrument to protect the vessels from injury. The dissection is then carried downward, carefully separating the pancreas from the mesenteric vessels. The blood vessels to the duodenum and upper 10 to 15 cm. of the jejunum are divided and ligated. The jejunum is divided between clamps, and the distal segment is passed through an opening in the mesocolon and anastomosed to the common duct and cut end of the pancreas. An

inner row of catgut and an outer row of silk sutures are used for these anastomoses. The gastrojejunostomy may be made either above or below the mesocolon. This anastomosis should be made 20 to 40 cm. distal to the choledochojejunostomy. The mesentery of the colon is closed about the jejunum and stomach. A drain should be placed through the abdominal wound down to the bed of the pancreas, but not in contact with any of the anastomoses. Whipple advises that the abdominal wound be closed with steel wire (see chapter on Abdominal Incisions).

Technique of Transduodenal Resection of Ampulla of Vater (Hunt and Budd) (Fig. 454)

An upper right rectus incision is made. The common duct above the duodenum is opened and explored for stones. An incision 3 or 4 cm. long is made in the anterior

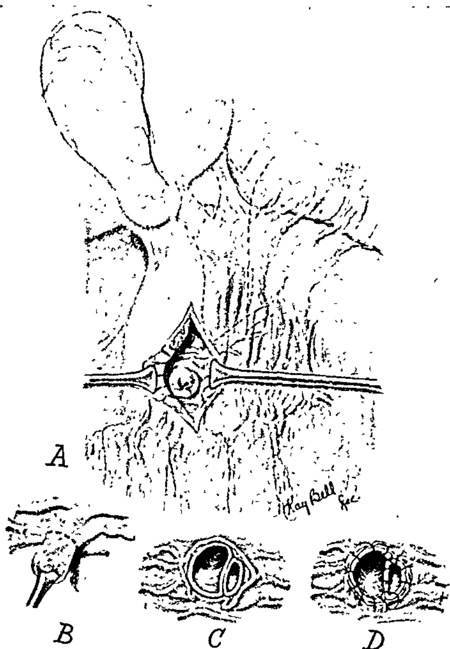


FIGURE 454. Technique of transduodenal resection of the ampulla of Vater for carcinoma *A*, Duodenum opened, exposing tumor of the ampulla. *B*, Line of incision about the ampulla. *C*, Cut ends of common duct and pancreatic duct after removal of tumor. *D*, Common duct and pancreatic duct sutured together and to wall of duodenum. (Redrawn from Hunt and Budd: Tr. West. S. A.)

duodenal wall parallel with its lumen directly over the ampulla. The tumor is excised, including the ampulla and distal ends of the bile and pancreatic ducts. Suction is required to maintain a clear field. The mesial cut edges of the common and pancreatic ducts are sutured together, and the circumference of each duct is sutured to the posterior wall of the duodenum. A short piece of rubber catheter is sutured into the pancreatic duct. The wound in the duodenum is closed transversely to avoid constriction. The common duct is drained with a T-tube. A cigarette drain is placed down beside the second portion of the duodenum. The abdominal wound is closed as in other operations on the gall tract.

Note. This operation is suitable only for small tumors involving the ampulla.

TOTAL PANCREATECTOMY

Complete removal of the pancreas, combined with duodenectomy, may be indicated in selected cases of benign and malignant tumors and diffuse calcification of the pancreas.

It has been shown experimentally in animals and also in patients that life is compatible with the absence of the external pancreatic secretion. Total pancreatectomy will produce diabetes which can be controlled with insulin and diet.

REMOVAL OF PANCREATIC STONES

General Considerations

Pancreatic lithiasis is a rare condition. The symptoms are not characteristic. Stones in the pancreas are often associated with stones in the gall tract. They are easily overlooked at operation for gallstones. A small percentage may be visualized by the x-ray when special care is used in film interpretation.

Dangers and Safeguards

Hemorrhage, necrosis from leakage of the pancreatic juice, and infection are the chief dangers. Early operation is desirable, since stones remaining in the pancreatic duct for a long time may result in fibrosis of the gland.

Technique

An incision is made into the pancreas parallel with the ducts directly over the stone, which is located by palpation. Trauma to the pancreas is avoided as much as possible. After removal of a stone the duct is explored with a small probe for other small stones. The wound in the pancreas is carefully closed with fine chromic catgut or silk. A drain is placed down to the pancreas.

Partial or complete pancreatectomy may be the operation of choice in cases of general calcification involving a portion or all of the pancreas.

Operations upon the Spleen, and Portal Hypertension

SPLENECTOMY

Indications

Splenectomy is usually the operation of choice when surgery of the spleen is indicated. Splenotomy, splenorrhaphy, splenopexy, partial splenectomy, and ligation of the splenic artery have a limited usefulness. An abscess of the spleen may be drained.

Dangers and Safeguards

The first essential for splenic surgery is adequate exposure. The spleen lies high against the left diaphragm, where it may be more or less adherent. Efforts to deliver the spleen into the abdominal wound may result in severe hemorrhage as a result of the tearing of large adhesions containing blood vessels, the tearing of the splenic capsule or laceration of the thin-walled veins of the splenic pedicle. Dense adhesions from perisplenitis may make splenectomy difficult.

If anemic, the patient should be transfused before operation, and whole blood should be available for transfusion during or after operation, although transfusion must be used with care in patients having hemolytic disease.

The stomach, colon, kidney, tail of the pancreas, and diaphragm must be identified and protected during operation Careless clamping of bleeding vessels may cause serious damage to one or more of these organs. With adequate exposure and careful dissection, nearby organs can be identified without difficulty, and bleeding can be controlled as the operation proceeds. In extreme cases, when removal of an adherent spleen may be dangerous to life, double ligation and division of the splenic artery may be substituted. The results of ligation are only temporary.

Postoperative thrombosis of the portal system may occur in a small percentage of cases. This is a serious complication which, unfortunately, cannot usually be satisfactorily treated. Heparin may prove of value in the prevention of this complication. When patients are in good general condition, the mortality rate of splenectomy is low.

Technique of Splenectomy (Figs. 455 to 459)

An inhalation or spinal anesthetic is used. A long left paramedian incision will usually afford sufficient exposure. It may be enlarged by a transverse incision across

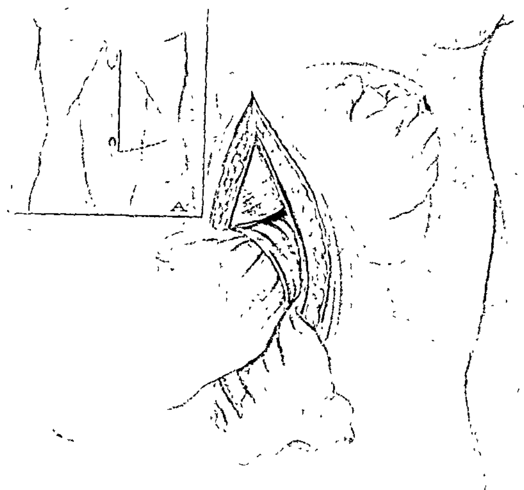


FIGURE 455 Splenectomy Insert shows line of incision. Mobilization of the spleen by blunt dissection with the fingers *(Hanrahan and Vincent. Lewis' Practice of Surgery, Vol. VI, W. F. Prior Co., Inc)*

the left rectus muscle and fasciae. A left subcostal incision also gives excellent exposure.

The abdomen is carefully explored for evidence of other disease and to note the size and relationships of the spleen. If the stomach is dilated, it should be emptied with a small tube passed by the anesthetist. The splenic artery should be isolated and ligated as the first step in splenectomy before mobilization of the spleen. This is especially important when the spleen is large or adherent to the surrounding structures. The spleen may shrink one third in size after ligation of the splenic artery. This artery is reached through the gastrocolic mesentery. In obese patients, it may not be readily seen, but can be located by palpation. Ligation or injury to the splenic vein is avoided. Preoperative intramuscular injection of 10 minims of epinephrine has been recommended to shrink the spleen and empty much of its blood into the general circulation.

The spleen is lifted or dissected free and delivered into the wound. This may be difficult if it is large and if many adhesions are present. Adhesions and the attachment to the posterior parietal peritoneum can usually be separated by finger dissection. Dense adhesions should be cut and clamped to prevent bleeding as the dissection progresses In some cases it may be necessary to doubly clamp and divide the vessels between the spleen and stomach (vasa brevia) before the spleen is completely de-

livered. As soon as the spleen is delivered into the wound, a large gauze pack moistened with physiologic sodium chloride solution is placed in the splenic bed. This helps to control oozing and prevents the spleen from slipping back into the abdomen.

The main splenic pedicle is identified from its posterior aspect, and, when possible, the artery is separated, doubly ligated, and divided if it has not already been ligated as noted above. By careful dissection small vessels and the vasa brevia are separated and clamped. The pedicle is carefully separated from the tail of the pancreas, which may be adherent to the hilum of the spleen. The vessels of the pedicle are separated and ligated. Three curved clamps may be placed on the pedicle, which is divided between the two nearest the spleen. A ligature of medium heavy chromic catgut or silk is passed about the pedicle proximal to the proximal clamp, and, as the ligature is tied, the clamp is removed so that the ligature is placed in the crushed line of this clamp. The distal clamp may then be removed safely.

The gauze pack is removed, and the left upper abdomen is carefully inspected for

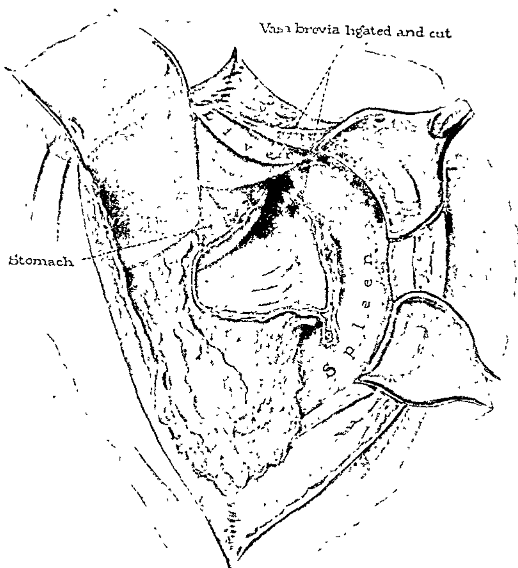


FIGURE 456 Splenectomy (*continued*) Exposure of the splenic pedicle. By cutting the gastrosplenic omentum, the vasa brevia arteries are divided and the lesser peritoneal cavity is opened, revealing the anterior fold of the pancreaticolienal ligament. The vessels of the splenic pedicle and the tail of the pancreas are enveloped by the anterior and posterior folds of this ligament (Hanrahan and Vincent: Lewis' Practice of Surgery, Vol. VI, W. F. Prior Co, Inc)

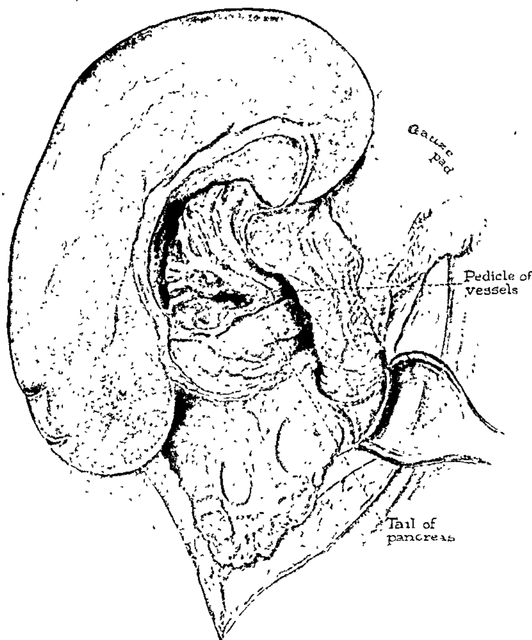


FIGURE 457. Splenectomy (*continued*) The spleen is delivered into the wound, exposing the pedicle and tail of the pancreas (Hanrahan and Vincent. Lewis' Practice of Surgery, Vol VI, W. F. Prior Co., Inc)

bleeding. All bleeding points are ligated or controlled with electrocautery. In rare cases it may be necessary to pack the splenic bed to control bleeding, but this should be avoided when possible because of the danger of wound infection.

When splenectomy is being done for thrombocytopenic purpura or for hemolytic anemia, a careful search must be made for accessory spleens. Patients with hemolytic anemia often have associated gallstones, and the gallbladder should be examined and removed if stones are present. Drainage is usually not necessary.

Technique of Splenectomy through a Thoracoabdominal Incision (Carter) (Figs. 460, 461)

An excellent exposure of the spleen can be obtained through a combined thoracoabdominal approach. This approach is the method of choice when the spleen is unusually large or adherent. Intratracheal anesthesia is advised. An incision is made

from a point midway between the xiphoid process and the umbilicus to the costal margin at the site of the eighth costal cartilage and from there extended in the eighth interspace to the scapular line. The muscles of the abdominal wall and chest wall, the peritoneum and pleura, and the eighth costal cartilage are incised. This incision exposes the diaphragm, which is in turn incised from its attachment at the costal margin to the posterior angle of the thoracic incision. By the use of a rib spreader a wide exposure of the splenic area is obtained.

Exposure and ligation of the splenic artery as it courses along the superior border of the pancreas is the first step. Any adhesions to the surface of the spleen are then divided under direct vision. The splenocolic, splenorenal and gastrosplenic ligaments are divided and ligated. The spleen can then be delivered through the incision. The tail of the pancreas can be visualized and easily separated from the splenic pedicle. With the exposure thus obtained the splenic vessels can be readily clamped, severed and ligated. The artery and vein should be ligated separately.

The wound in the diaphragm and the thoracoabdominal wound are closed with interrupted sutures of silk. The ends of the divided cartilage are united with silk

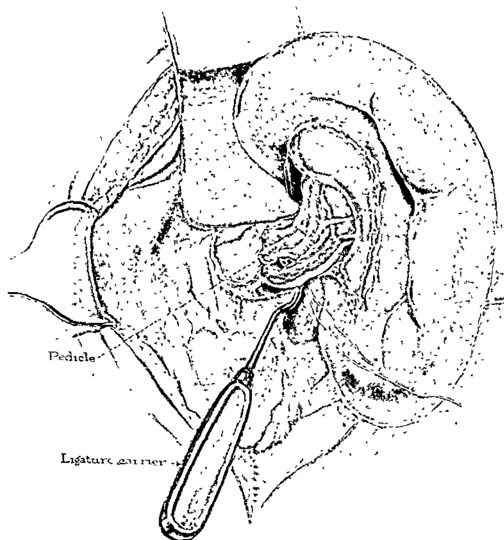


FIGURE 458. Splenectomy (*continued*) Ligation of the pedicle after identification and separation of the vessels It is safer to ligate the pedicle in sections. (Hanrahan and Vincent: Lewis' Practice of Surgery, Vol. VI, W F. Prior Co., Inc)

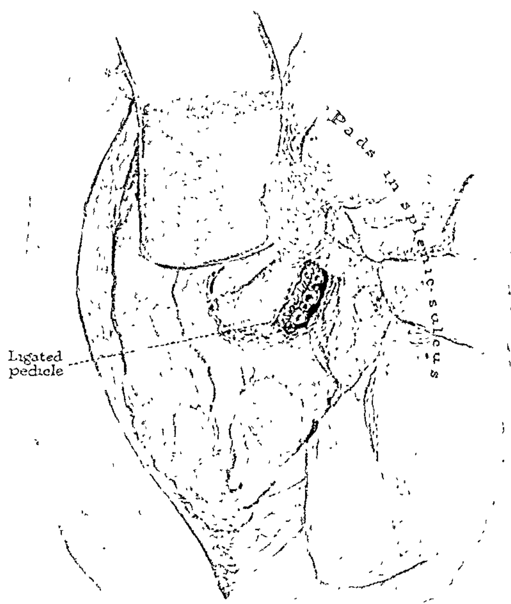


FIGURE 459 Splenectomy (*concluded*) After securely ligating the pedicle, the gauze pack is carefully removed and the splenic bed is inspected for bleeding (Hanrahan and Vincent Lewis' Practice of Surgery, Vol VI, W F Prior Co., Inc)

FIGURE 460 Technique of splenectomy through a thoracoabdominal incision Insert shows location and extent of the incision The incision has been extended through all tissues down to the peritoneum and pleura except the eighth costal cartilage. (Carter: Surg , Gynec. & Obst , Vol. 84. By permission of Surgery, Gynecology and Obstetrics.)

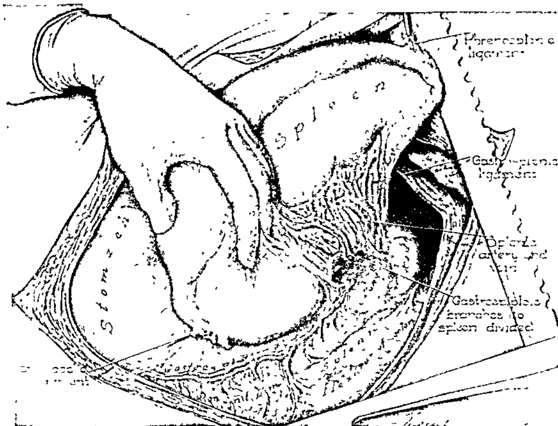


FIGURE 461. Technique of splenectomy through a thoracoabdominal incision (*concluded*) The spleen has been mobilized by dividing the splenocolic, splenorenal and gastrosplenic ligaments The splenic pedicle has been separated from the tail of the pancreas. The gastroepiploic vessels to the spleen have been divided and ligated The splenic pedicle is freed ready for ligation. (Carter: Surg , Gynec. & Obst , Vol. 84 By permission of Surgery, Gynecology and Obstetrics)

stitches placed in the perichondrium. Waterseal drainage of the chest is indicated for twenty-four to forty-eight hours.

PORTACAVAL SHUNTS

General Considerations

There are various procedures devised to overcome bleeding esophageal varices associated with portal hypertension. The shunting of blood from the portal system to the systemic venous circulation has been the most satisfactory. This can best be accomplished by anastomosing the splenic vein to the left renal vein or by anastomosing the portal vein to the vena cava. Approximately 80 per cent of esophageal varices are associated with Laennec's cirrhosis, most of the remainder being due to extrahepatic portal bed block. Since many of these patients are poor surgical risks, owing to severe liver disease, the selection of patients for operation is important. Likewise, careful preparation of the patient is essential, and modern medical therapy often results in a great improvement in general liver function. This fact has increased the importance of shunting procedures, since the life expectancy of the cirrhotic patient can be greatly improved by proper medical management.

In many instances roentgenographic visualization of the portal venous system

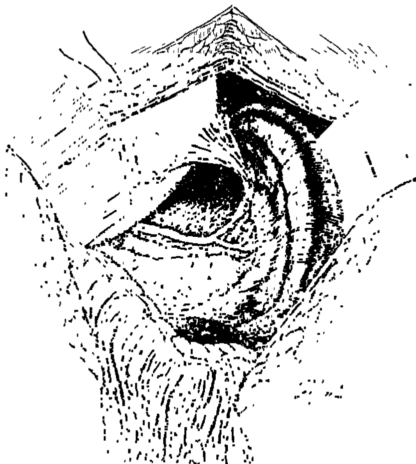


FIGURE 462. Splenorenal anastomosis The gastrocolic ligament has been clamped and divided and the splenic flexure retracted downward A ligature is placed around the splenic artery as it courses along the superior margin of the pancreas (C E. Sedgewick and C M Parrish S Clin. North America, Vol. 35)

by splenoportography may be of help in deciding which shunting procedure is advisable. This is accomplished by the injection of 50 cc. of 70 per cent Urokon or Diodrast through the eighth or ninth left intercostal space directly into the spleen, after which a roentgenogram is taken.

Technique of Splenorenal Anastomosis (Figs. 462, 463, 464)

Endotracheal anesthesia is used. The patient is placed in the semilateral position with the left side supported by sand bags. Exposure is best obtained by use of a combined thoracoabdominal incision extending from the region of the umbilicus upward and lateral to the costal margin and continuing through the eighth intercostal space well posterior. Careful attention to hemostasis is essential. The diaphragm is then divided between clamps along the line of the skin incision. The abdomen is next explored and the portal pressure determined. The gastrocolic ligament is then divided between clamps and the greater curvature side of the stomach completely freed by ligation and division of the short gastric vessels. The splenic flexure is then freed from its attachments and retracted downward. The splenic artery is then isolated along its course in the superior margin of the pancreas and ligated. This permits mobilization of the spleen forward into the wound. The terminal portion of the splenic vein is then mobilized by careful dissection and ligation of the small pancreatic branches. When

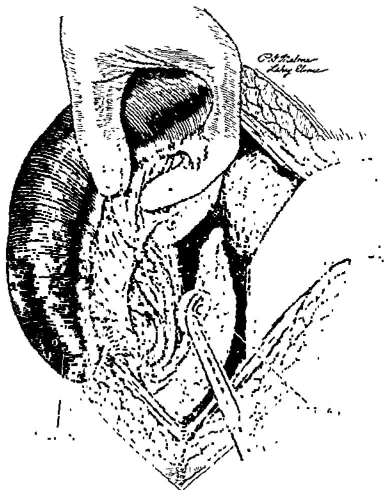


FIGURE 463. Splenorenal anastomosis (*continued*) The spleen has been mobilized and retracted into the wound to permit isolation of the splenic vein Care must be taken in dividing and ligating the venous tributaries from the pancreas to the splenic vein. (C. E. Sedgewick and C. M. Parrish· S. Clin North America, Vol. 35.)

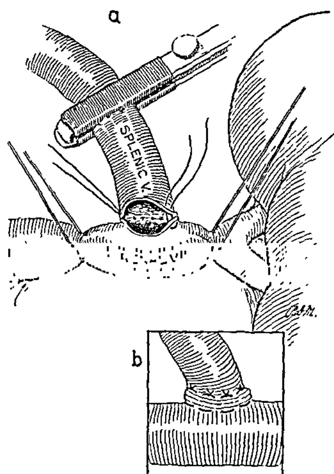


FIGURE 464. Splenorenal anastomosis (*concluded*). End-to-side anastomosis between the splenic vein and renal vein, using interrupted everting mattress sutures (C. E. Sedgewick and C M. Parrish· S. Clin North America, Vol. 35.)

approximately 8 cm. of the splenic vein have been mobilized, the remaining structures of the splenic hilum are clamped, divided and ligated and the spleen removed.

Bleeding from the end of the splenic vein is controlled by a bulldog type of clamp or by an umbilical tape. The left kidney is then exposed by dividing the posterior parietal peritoneum. Depending upon the anatomic configuration, it may or may not be necessary to mobilize the kidney completely. The renal vein is then isolated for approximately 5 cm , care being taken to ligate and divide all small tributaries in this segment. Umbilical tapes are then passed around the isolated segment of renal vein, both proximal and distal, to control bleeding from this vessel. Some authors prefer also to isolate the renal artery at this point and temporarily occlude the arterial flow to the kidney while the anastomosis is being performed. If the renal vein is of sufficient size, only a portion of its lumen can be occluded with one of the special vascular clamps An opening is then made in the renal vein the same length as the diameter of the splenic vein. The anastomosis is then performed, using either interrupted everting mattress sutures or a running over-and-over stitch if preferred The end of the splenic vein and the isolated portion of the renal vein should be flushed with dilute heparin. It may be advisable to release temporarily the clamp on the splenic vein when the posterior layer of sutures has been placed to flush out any clots which may have accumulated in the vein.

After completion of the anastomosis the clamp on the splenic vein is released to test the suture line for leaks Any small leaks present can usually be controlled by mild pressure. The occluding ties on the renal vein are then released. A rubber tissue drain is placed in the region of the tail of the pancreas, and the wound is closed in routine fashion. A waterseal drain is placed in the chest through a stab wound.

Technique of Portacaval Anastomosis (Figs. 465, 466)

Anesthesia and exposure are obtained as for splenorenal anastomosis except that a right thoracoabdominal incision is used. After exploration of the abdomen the portal pressure is determined. The liver is retracted upward into the thoracic cavity, and the hepatic flexure is freed and retracted downward. The lateral peritoneal attachment of the duodenum is then divided, permitting the duodenum to be retracted downward and medialward. The portal vein above the entrance of the renal vein is freed from surrounding fat and areolar tissue. Tapes may be passed around the vena cava both proximally and distally for control of possible bleeding; however, care must be taken not to injure the lumbar veins, which enter posteriorly and laterally. The portal vein is next identified and mobilized from the other structures of the porta hepatis. Care must be taken not to injure the biliary ducts and hepatic artery. Lymph nodes are often present in this area and must be excised. A long segment of the portal vein is mobilized and the vein divided as high in the hilum of the liver as possible, the upper segment being secured with ligature and transfixion ligature. Bleeding from the proximal stump is temporarily controlled by a bulldog clamp or by umbilical tape.

The vena cava is then partially occluded by one of several different types of clamps which have been devised for this purpose and an opening made to accom-

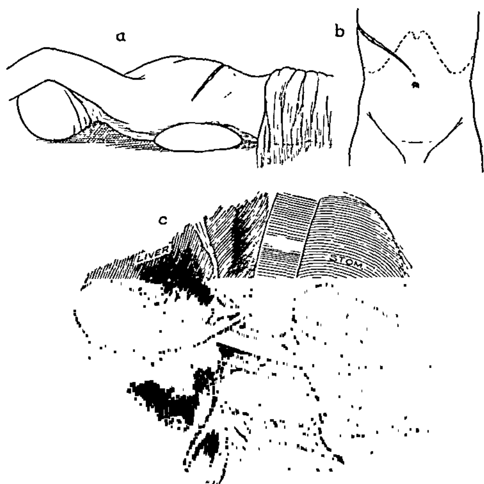


FIGURE 465. Portacaval anastomosis *a* and *b*, Position of the patient and the combined thoracoabdominal incision *c*, The hepatic flexure has been retracted downward and the lateral peritoneal attachment of the duodenum divided to permit its mobilization The inferior vena cava and portal vein have been partially mobilized (C E Sedgewick and C. M. Parrish· S. Clin. North America, Vol 35)

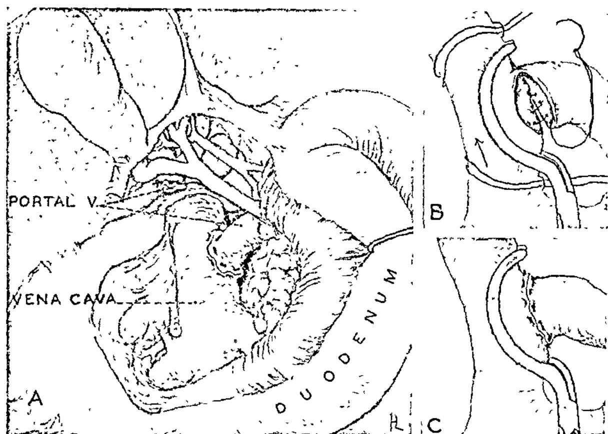


FIGURE 466. Technique of portacaval anastomosis *A*, Completed anastomosis *B*, Posterior continuous silk suture applied to evert the margins of the wounds. *C*, Completed anastomosis, showing anterior everting suture. (Redrawn from Welch. Surg., Gynec and Obst, Vol 85)

modate the end of the portal vein for an end-to-side anastomosis. The anastomosis can be made with either interrupted or running everting mattress sutures, or some authors prefer a simple over-and-over stitch. When the anastomosis has been completed, the portal vein is released and the anastomotic line examined for leakage. Any leakage usually responds to slight pressure, although it may be necessary to insert an additional stitch or two. The clamp is then removed from the vena cava. The entire area is checked for bleeding and the incision closed. Drainage of the chest with a waterseal drain for twenty-four to forty-eight hours is advisable.

Operations upon the Small Intestine

Anatomy

The small intestine begins at the pylorus and ends at the ileocecal valve. Its entire length is approximately 6.75 meters in the adult. The duodenum is about 25 to 30 cm. long. The jejunum measures about 2.5 meters and the ileum 4 meters, or three fifths of the small intestine. The small intestine decreases in size from the duodenum to the ileum.

The duodenum is the fixed portion of the small intestine. It ends at the ligament of Treitz. The mesentery of the jejunum and ileum is attached to the posterior abdominal wall over a distance of about 15 cm., extending in an oblique line from the left side of the second lumbar vertebra to the region of the right sacroiliac articulation.

Differentiation between the jejunum and ileum at operation is not always possible, but may be aided by the size of the bowel, variation in the mesenteric blood vessels, and the location of the mesenteric attachments. In the upper jejunal mesentery, the loops of vessels are larger and more clearly outlined than in the lower mesentery. From above downward the vessel loops become smaller and more irregular, and are obscured by fat as the ileocecal valve is approached.

Anomalies of the small intestine and its attachments are few, but may be of surgical importance. The superior and inferior duodenal fossae at the ligament of Treitz and the superior and inferior ileocecal fossae may be the sites of internal hernias resulting in intestinal obstruction. Meckel's diverticulum, which persists in a small percentage of people, is usually found from 0.33 to 1 meter above the ileocecal valve Its length is usually 5 to 7 cm. It may pro-

duce infection, perforation, adhesions with bowel obstruction, or bleeding peptic ulcer.

Dangers and Safeguards

The inexperienced operator may operate upon the colon when the operation was intended for the small intestine, or vice versa. The large intestine can be easily identified by its longitudinal bands. A distended and hypertrophied small intestine may be as large as the colon. Adhesions, inadequate exposure and lack of familiarity with abdominal anatomy may lead to an error in identification of structures.

Unnecessary *trauma* to the intestine and peritoneum, evisceration, bleeding and prolonged operation predispose to shock. *Wound soiling* is dangerous from any portion of the large or small intestine. It is important to know that this danger increases as the distance increases from the pylorus. The contents of the upper intestine contain fewer pathogenic bacteria than the lower. Obstructive lesions of the small intestine increase the bacterial content of the bowel. Extensive contamination of the peritoneum by contents of the distended small bowel is likely to be fatal. Any operative procedure on the small bowel must be preceded by properly protecting the operative field with moist gauze packs and by emptying the segment of bowel to be opened to avoid spillage. An operation upon the intestine must be watertight when finished. Leakage about poorly placed sutures will result in fatal peritonitis in a high percentage of cases.

A resection must be done without endangering the blood supply to the bowel. The danger point in bowel anastomosis is at the mesenteric border, where vessels may be stripped from the bowel wall or sutures so placed that the blood supply is strangulated, resulting in necrosis and leakage. The protective value of the omentum placed over suture lines in the intestine cannot be too strongly emphasized. Careful closure of mesenteric and omental defects prevents the possibility of later intestinal strangulation. Drainage material placed in the abdomen should not be in contact with suture lines. Pressure clamps placed on the bowel to control bleeding and flow of the bowel content should not be so tight as to cause tissue destruction.

ENTEROTOMY

Technique of Enterotomy

This operation is most frequently done to remove a foreign body. The section of bowel to be opened is withdrawn from the wound and protected by gauze packs. Rubber-shod clamps are placed proximal and distal to the point of incision to protect against intestinal content soiling. A transverse incision long enough to explore or remove a foreign body is made. Soiling is avoided by careful sponging or suction. The wound is closed transversely with a double row of sutures. Care is used not to produce partial occlusion of the lumen by turning in too much of the wound margin. A continuous lock-stitch suture of no. 00 chromic catgut is satisfactory to unite the wound margins. This row of sutures is reinforced with interrupted Lembert sutures of fine silk. Drainage is seldom necessary.

ENTEROSTOMY

General Considerations

Enterostomy may be indicated for bowel drainage or for direct intestinal feeding. When the latter is desirable, a high jejunostomy is the enterostomy of choice. A rubber tube or catheter introduced into the bowel is usually preferable to suturing the bowel wall to the skin. After removal of a properly placed rubber tube the opening in the bowel will close spontaneously. If the bowel wall is sutured to the skin and drained, later surgical closure may be necessary.

Local anesthesia is the choice for very ill patients unless extensive abdominal exploration is contemplated.

Technique of Witzel Enterostomy (Figs. 467, 468, 469)

An incision is made through the abdominal wall as near the site of the proposed enterostomy as possible. A loop of bowel approximately 15 cm. long is withdrawn from the wound. Rubber-covered intestinal clamps are placed on the bowel to control the flow of intestinal content. When possible to determine, the proximal end of the loop is selected for insertion of the drainage tube. If the bowel wall is thin, the segment of gut should be emptied with trocar and suction before any stitches are placed. If the

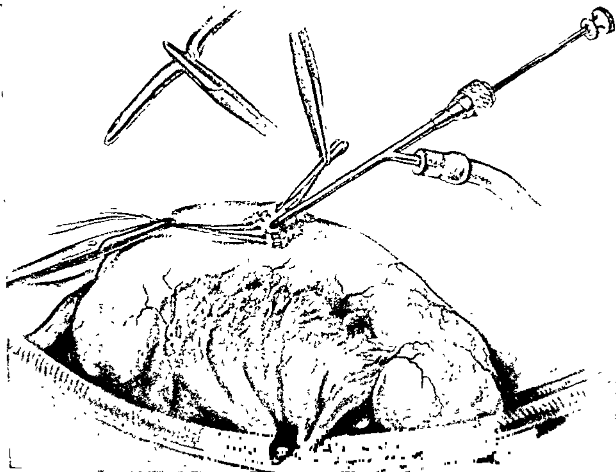


FIGURE 467 Technique of Witzel enterostomy Bowel content controlled with rubber-shod clamps. Two purse-string sutures are placed, and the bowel is emptied by suction through a trocar. A catheter is used for drainage

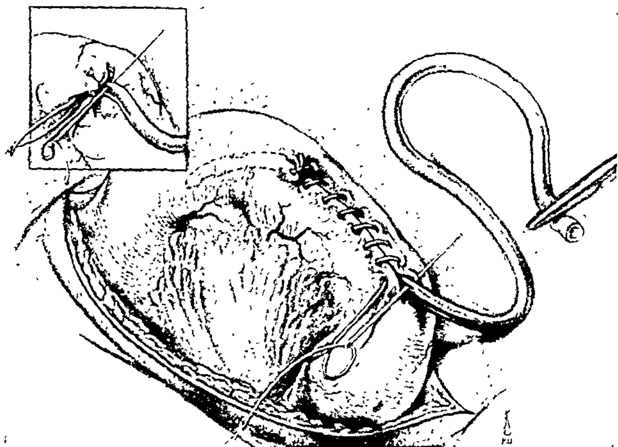


FIGURE 468. Technique of Witzel enterostomy (*continued*) Method of fixing catheter to prevent accidental withdrawal and imbedding catheter in the bowel wall.

bowel wall is thickened and hypertrophied, carefully placed sutures will not cause leakage.

A purse-string suture of no. 00 chromic catgut is placed about a space on the gut wall a little larger than the caliber of the drainage tube. A second purse-string suture of the same type is placed about 0.5 cm. from the first. All gas and liquid are removed from the isolated loop by a trocar passed through the gut wall within the circle of the first purse-string suture. As the trocar is withdrawn, a no. 16 or 18 French catheter, with two or three openings near the tip, is introduced about 5 cm. The inner purse-string suture is tied about the catheter, and the catheter is fixed in place by passing the needle through its wall. The suture is tied and cut away. The second purse-string suture is tied as the gut wall is invaginated by the attached catheter. The catheter is then held in a groove in the bowel wall, and the second purse-string suture is used to bury the catheter in the folded wall a distance of 6 to 7 cm. A continuous Lembert suture is used and fixed at the end by passing it through the catheter wall. The needle should not puncture the catheter lumen. When possible, the free end of the catheter is passed through the omentum, and the omentum is fixed over the suture line with two or three catgut sutures. The omentum minimizes both the possibility of leakage and adhesions to the abdominal wall.

The abdominal wound is closed about the catheter, or the catheter may be passed through a small stab wound. It is wise to fix the catheter to the skin with a fine silk suture to prevent its accidental withdrawal. The suture may be passed through adhesive tape placed about the tube at the skin surface.

This operation can be done without any wound soiling if the bowel is emptied by

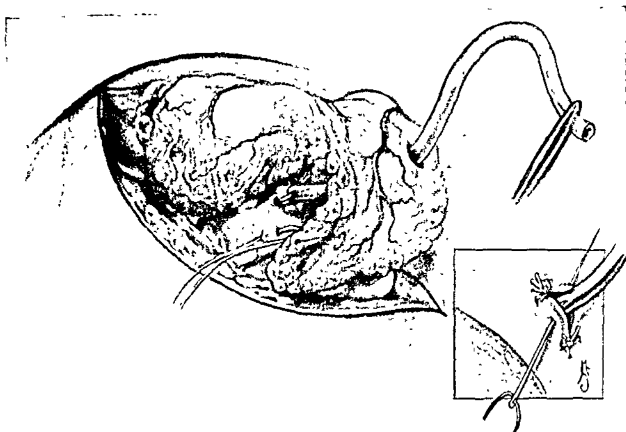


FIGURE 469. Technique of Witzel enterostomy *(concluded)* To protect suture line, catheter is passed through omentum, and omentum is fixed to bowel wall with sutures Stitch passed through wall of catheter to fix it to wound margin.

suction before the catheter is introduced. With careful technique, the protective intestinal clamps are often unnecessary.

If a jejunostomy for intestinal feeding is planned, it should be made high in the jejunum, allowing only sufficient length of bowel to avoid the transverse colon. An upper left abdominal quadrant incision is the choice.

END-TO-END ANASTOMOSIS WITH RANKIN CLAMP

Technique of Anastomosis (Fig. 470)

Although most surgeons today prefer the "open" technique of intestinal anastomosis, the occasion may arise—as, for example, the necessity of resecting an unprepared colon—when the "closed" anastomosis is essential. For this reason every surgeon should be familiar with this technique. Special clamps may simplify the placement of sutures; however, they are unnecessary.

At the site chosen for anastomosis the bowel is grasped in the jaws of a Rankin clamp. The section of bowel to be removed is clamped to control soiling, and cut away with a cautery flush with the Rankin clamp. The clamp is placed on the bowel obliquely so that more of the antimesenteric than mesenteric portion will be removed. This is done to increase the size of the bowel lumen and to protect the blood supply.

After draping the operative field with moist protective gauze, the clamp is turned over, exposing the side with the single or middle blade. Over this a continuous Lembert suture of no 00 chromic catgut is placed from one end of the clamp to the other.

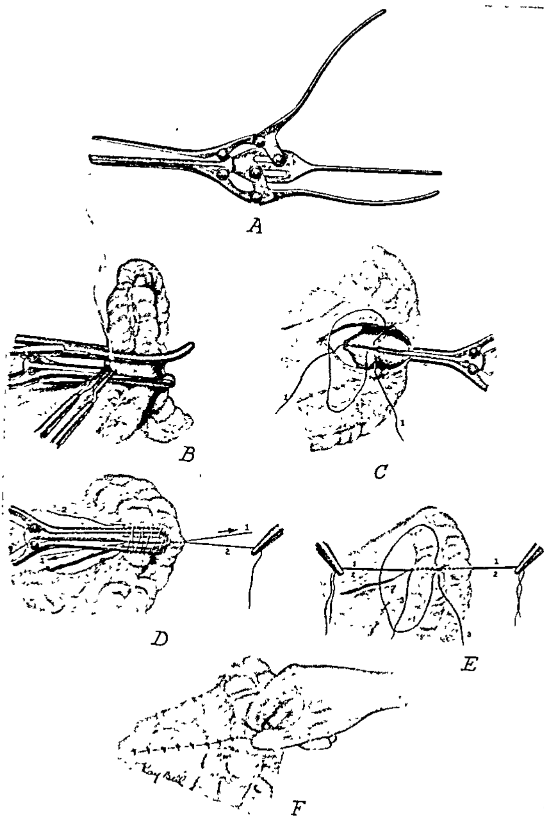


FIGURE 470 Technique of resection and end-to-end anastomosis of the intestine by the Rankin method *A*, Rankin clamp *B*, Bowel divided with cautery along Rankin clamp. *C*, Continuous suture of bowel over middle blade of Rankin clamp *D*, Continuous Cushing suture over lateral blades of Rankin clamp *E* Sutures drawn taut and tied Seromuscular suture being placed Interrupted Lembert sutures are often preferred to continuous suture *F*, Anastomosis and suture of mesentery complete. Finger invaginated to open and test lumen of gut

The suture is tied at each end, leaving the ends long. The clamp is then turned back into its original position, and a second suture of the continuous Cushing type is placed over the clamp. The stitches should not penetrate the mucosa. The ends of this suture are held for fixation. Each end of the anterior suture is grasped and drawn taut as the three-bladed clamp is carefully withdrawn. This maneuver turns in the gut margins, approximating serosa to serosa. Both anterior and posterior sutures are tied together at each end and held for traction. A second row of interrupted Lembert or Halsted fine silk sutures is applied around the bowel. This completes the anastomosis. The lumen of the bowel is opened by invaginating the finger above or below the suture line to break open the diaphragm formed by the crushing clamp. The mesentery is carefully closed with interrupted sutures.

A lateral colocolostomy, an end-to-side enterocolostomy or a lateral entercolostomy may also be made by this technique.

PARKER-KERR ASEPTIC "BASTING STITCH" INTESTINAL ANASTOMOSIS

Technique (Fig. 471)

The bowel is sectioned with a cautery or knife between clamps placed at an angle of 45 degrees, making the acute angle at the mesenteric border. This doubles the lumen of the gut and prevents obstruction where a diaphragm is turned in to approximate serosa to serosa. All tissue is cut or burned away flush with each clamp.

The basting stitch is then placed over the clamp as a continuous Cushing suture. This is drawn taut as the clamp is withdrawn, turning in the end of the bowel. The two bowel ends closed with Cushing sutures are held in contact with the projecting ends of the basting stitches while the anastomotic suture is being placed. Interrupted Lembert or Halsted sutures are used. This suture must include the submucous layer of the bowel. After the sutures have been placed the basting stitches are clipped and withdrawn. This completes the anastomosis. The infolded diaphragm is opened by finger invagination of the bowel wall near the suture line The mesentery is closed with interrupted sutures. Chromic gut or fine silk may be used as suture material. End-to-end anastomosis may be made between sections of bowel of different caliber by slightly puckering the larger opening with the basting stitch. Lateral and end-to-side anastomosis may also be made by this method.

RESECTION OF INTESTINE AND END-TO-END ANASTOMOSIS

Technique (Fig. 472)

The section of bowel to be removed is lifted from the abdomen, and the operative field is protected with warm moist pads. At the points of section Ochsner clamps are placed on the bowel at an angle of 45 degrees so that more of the antimesenteric than the mesenteric portion is removed. This not only increases the size of the opening in the bowel to be united, but also removes that portion to which the blood supply might be deficient. The mesentery of the segment to be removed is then clamped and all vessels carefully ligated with fine catgut A V-shaped section of the mesentery should

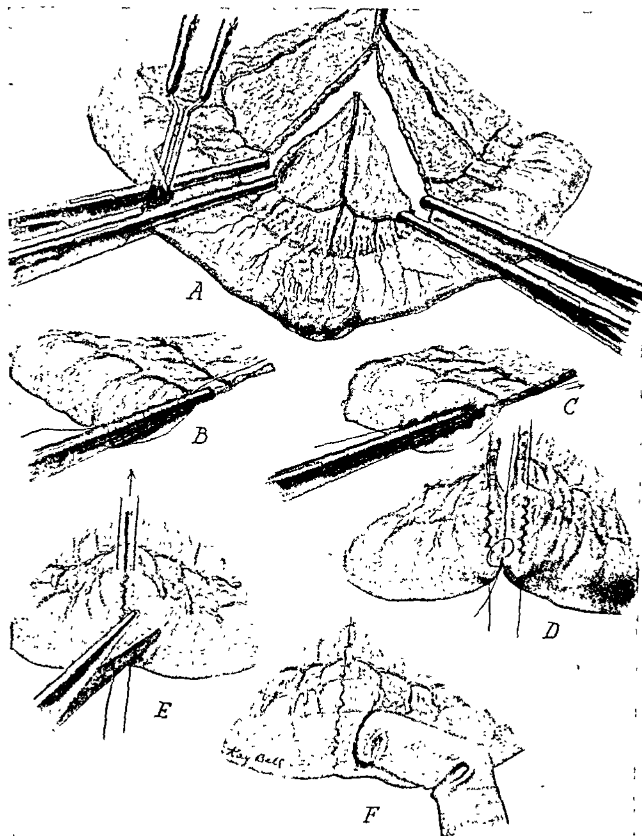


FIGURE 471 Technique of the Parker-Kerr "basting stitch" intestinal anastomosis *A*, Section of bowel with mesentery removed between clamps with cautery *B*, Continuous Cushing suture placed over clamp *C*, Clamp withdrawn and suture drawn taut to invert end of bowel. *D*, Ends of bowel approximated with "basting stitch" sutures while anastomosing sutures are placed *E*, "Basting stitch" sutures cut and withdrawn *F*, Invagination of finger to open lumen of bowel.

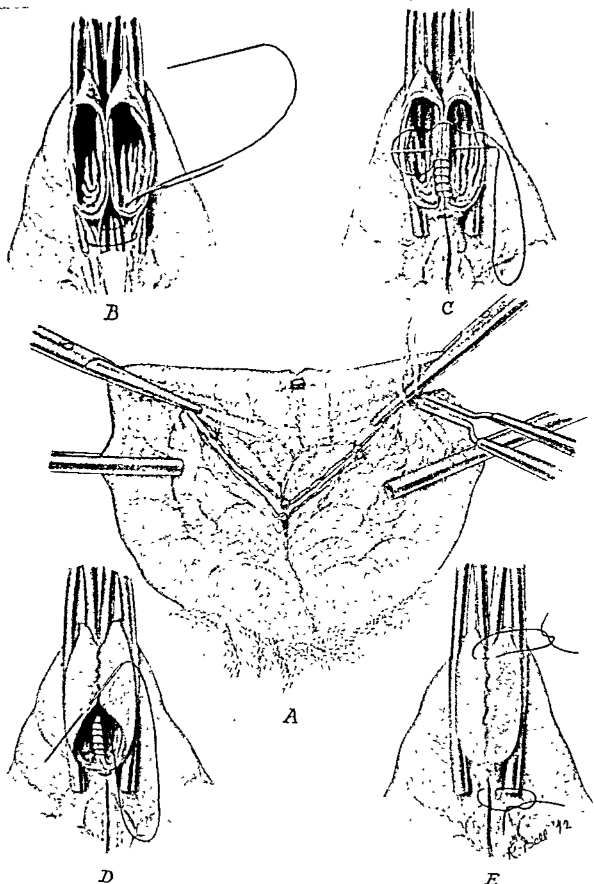


FIGURE 472 Technique of resection of intestine and end-to-end anastomosis. *A*, Portion of small gut resected with mesentery *B*, Stitch placed to close triangular space at mesenteric attachment. *C*, Sides of bowel have been united with seromuscular sutures, and an inner lock-stitch suture is being placed. *D*, Connell inverting suture. *E*, Beginning last row of interrupted Lembert seromuscular sutures and interrupted sutures in mesentery.

be removed if involved in the pathologic process. To prevent soiling, this step in the operation is completed by preference before the bowel is sectioned.

Rubber-shod clamps are placed on the bowel a few centimeters from the points of section to control the bowel content. The bowel is then sectioned with knife or cautery against the Ochsner clamps previously placed. The clamps are removed, and the open ends of the bowel are immediately cleansed by suction and sponging. The mesenteric attachment at the point of section should be left intact to avoid disturbance of blood supply. There is a triangular space formed by the mesentery at its junction with the bowel where the gut wall is not covered with peritoneum. Leakage and infection may result if this space is not closed. This space may be closed with a single suture or by the first suture placed at the beginning of the anastomosis.

The margins of the open bowel are controlled with small hemostats or Allis clamps. The first stitch passes through the walls and is so placed that, when it is tied, it closes the triangular space. This suture is then continued as a lock stitch or Connell stitch to the antimesenteric border, where it is again tied. From this point it is continued as a Connell stitch to close the open bowel completely. This first row of sutures is then inverted with interrupted Lembert or Halsted sutures to complete the anastomosis. Enough of the margin should be turned in to ensure snug approximation of peritoneum to peritoneum. Too much invagination of the bowel wall will form a diaphragm which might result in bowel occlusion. Sutures of fine chromic catgut may be used throughout, or fine silk may be used for the second row of interrupted sutures.

The mesentery is closed with interrupted sutures of catgut placed close to the wound margins to avoid damage to the blood supply of the bowel.

EXTERNAL DUODENAL FISTULA

General Considerations

Operative procedures are usually not indicated for the closure of duodenal fistulas. Patients having such fistulas are usually poor operative risks, and the technical difficulties, such as edema, exudate, and friability of tissues, make successful surgical attack doubtful. Selected cases may be treated by gastroenterostomy and occlusion of the pylorus with a ligature. Because of the operative hazard, this treatment is usually contraindicated. Jejunostomy with jejunal feeding may be successful in some cases.

The loss of essential upper gastrointestinal tract secretions through a large duodenal fistula may result in death. Careful replacement of fluid and electrolyte loss is essential. Liquid feeding may be administered through a small tube of the Miller-Abbott type passed through the stomach and duodenum into the upper jejunum.

Most small fistulas will close spontaneously if continuous suction is applied. This may be accomplished by a small rubber tube or catheter passed partway into the fistulous tract and attached to a small motor or water-pressure suction tap for continuous suction. This may be supplemented for a limited time by continuous gastric suction to minimize the quantity of liquid passing into the duodenum or by feeding through a tube passed beyond the duodenum into the upper jejunum.

CLOSURE OF SMALL INTESTINAL FISTULA

Technique

The extent and location of the fistula are determined by injection of an opaque medium and study with the x-ray.

If the fistula is short, it may be repaired through an incision made about the external opening to remove the scar and open the abdomen. The margins of the opening into the bowel are freed of scar tissue and closed with a double row of fine chromic catgut placed transversely across the bowel. If the opening into the bowel is large, it may be advisable to excise a short segment, to be followed by end-to-end or lateral anastomosis.

When the fistulous tract is long or if difficult dissection is anticipated, it is wiser to open the abdomen through a new incision and approach the fistula from the peritoneal side.

After repair of the fistula the suture line should be covered with omentum. Drainage is seldom necessary.

Technique of "Button" Closure (Cattell)

The "button" type of closure is suitable for small openings when the gut lies in close proximity to the abdominal wall. Ordinary clothing buttons, of the two-hole type, are satisfactory. The size of the button to use depends upon the size of the fistulous opening. The inside button should be slightly larger than the opening, but may be smaller than the outside button.

The button to be used on the intestinal side is threaded with heavy silk. It is pushed into the intestine with the convex side toward the abdominal wall. The external button is threaded on the silk with the convex side downward. The two buttons are then tied together snugly, closing the fistulous opening. If the suture is tied too tightly, pressure necrosis of the abdominal wall may result. The button is sealed over with cotton and collodion to make it waterproof.

As the edema of the abdominal wall decreases, the buttons loosen and require repetition of the procedure. The buttons are left in place until granulations fill the fistulous opening. The holding suture is finally cut, permitting the inside button to pass through the intestinal tract.

If the foregoing treatment fails or if the fistula is not amenable to such treatment, it may be necessary to open the abdomen, free the fistula, and close the opening in the bowel with a double row of sutures.

EXCISION OF MECKEL'S DIVERTICULUM

General Considerations

Meckel's diverticulum usually arises from the ileum about 1 meter from the ileocecal junction. It varies from a slight bulging on the antimesenteric border of the gut to 20 cm. in length. Its caliber may be as small as an appendix or as large as the ileum. It may be the cause of intestinal obstruction, perforation, hemorrhage from a

careful attention must be given to the viability of the gut. If, after the cause of the strangulation is relieved, the blood supply does not return to the involved segment within a few minutes by treatment with hot moist packs, the gut should be resected or exteriorized. If the bowel is considered viable with no necrotic patches, it is returned to the abdomen. With the proper use of the Wangensteen or Miller-Abbott tube enterostomy may be eliminated in many cases.

Exteriorization of the bowel is done by lifting the entire involved segment outside the abdomen and closing the wound about the two arms of the gut. If the obstructed end of the gut is thickened or hypertrophied, it may be sutured to the distal end by the Mikulicz method to be treated later by crushing the spur and closing the fistula. If the obstructed portion is thin and overdistended, stitches might cause leakage and are to be avoided unless the gut is first emptied. The damaged segment is cut away, and a catheter or small tube is sutured into the protruding proximal bowel for drainage and for prevention of abdominal wall excoriation. After symptoms of obstruction have abated, the bowel may be freed from the abdominal wall and reunited by an end-to-end or lateral anastomosis. If the Mikulicz technique is used, the spur is broken down with a heavy clamp, and the fistula is later closed with a double row of interrupted sutures of no. 00 chromic catgut.

Tumors of the small intestine producing obstruction usually require resection. Resection of Meckel's diverticulum is indicated when involved in obstruction of the small bowel.

PLICATION OF THE SMALL INTESTINE FOR RECURRENT OBSTRUCTION

General Considerations

The procedure of suturing together loops of bowel and mesentery was devised by Noble in a deliberate effort to produce controlled adhesions in order to prevent recurrent intestinal obstruction. Other authors, notably Poth and Seabrook, have reported fairly extensive experience with the procedure with favorable results. This procedure may be indicated when extensive adhesions are found, even though there is no history of intestinal obstruction, as well as in those patients with a history of chronic or recurrent obstruction. In the presence of acute intestinal obstruction it is essential to relieve distention either by use of a long intestinal decompression tube or by proximal enterotomy and suction. The procedure may be extremely tedious and time-consuming and accompanied by considerable loss of blood, fluid and electrolytes. Therefore provision for replacement therapy before and during the operation is necessary.

Technique of Operation (Noble) (Fig. 473)

The abdomen is opened and the loops of adherent bowel freed. This, of course, may be a time-consuming procedure accompanied by considerable loss of blood and fluids because of the large denuded areas left after separation of the adhesions.

The amount of bowel to be plicated may vary from a short segment to the entire small intestine. A single unit of plication is the basis for the entire procedure. Each loop of bowel, the arms of which are to be sutured together, will be from 6 to 9 inches

in length. When the two loops of bowel to be sutured are approximated, it will be seen that a fold exists in the mesentery. In order to eliminate the resulting pocket, the edges of the fold in the mesentery are sutured together, starting at the base of the mesentery and proceeding outwards to the bowel. This is done with a running suture of fine chromic catgut, and when the bowel edges are reached, the suture is tied in continuity. The suture is then continued to appose the two arms comprising the bowel loop. Although there is some difference of opinion, it is believed preferable to place the suture line approximately midway between the mesenteric and antimesenteric border of the bowel, and to use a continuous suture of catgut. Barron and Fallis recommend that all sutures be placed in the bowel mesentery and none in the bowel wall and prefer interrupted silk sutures. This prevents kinking or a tendency for the loops to pull apart when the bowel becomes distended. Succeeding loops of bowel are then plicated to the preceding loops as illustrated until the entire area of involved bowel has been plicated. Thus it will be seen that each succeeding loop will be pointed

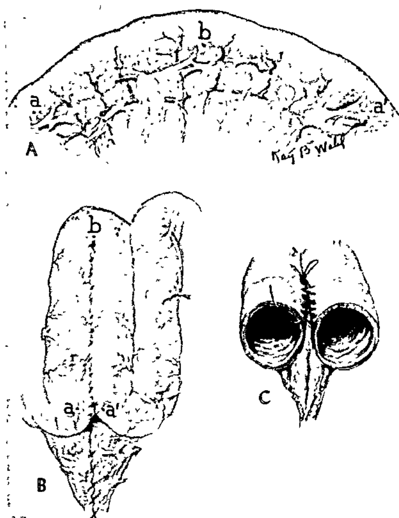


FIGURE 473. Noble plication for intestinal obstruction *A*, Section of bowel after lysis of adhesions. The points *a* and *a'* are approximated to constitute a unit. Each arm of the unit should be about 6 to 9 inches in length. *B*, Completed unit of plication. When points *a* and *a'* are approximated, the resultant fold in mesentery must be closed, starting at the base and proceeding outward to avoid formation of a pocket. *C*, Detail of placement of continuous suture between arms of a unit to lie midway between the mesenteric and antimesenteric borders of the bowel.

in the opposite direction. When the plication has been completed, the abdomen is closed without drainage. Postoperatively, nasogastric suction is continued until peristalsis has returned, after which liquids by mouth are resumed and feeding gradually increased to a regular diet.

INTUSSUSCEPTION

General Considerations

This condition is usually found in apparently healthy infants, although adults are not exempt. It may occur in any portion of the intestinal tract, but the ileocolic type, beginning at the ileocecal valve, is the most common. The treatment is essentially surgical, although some good reports of nonoperative treatment with enemas and hydrostatic pressure in early cases have been published.

Dangers and Safeguards

Temporizing measures are dangerous, especially in infants. Intestinal obstruction and damage to the blood supply of the bowel wall will rapidly lead to death unless promptly relieved by operation. Dehydration must be treated with physiologic sodium chloride, Ringer's solution or Hartman's solution. Infants tolerate extensive and prolonged operations very poorly. If the bowel is opened or torn, peritonitis will develop in many cases. The minimum operative procedure to effect reduction is indicated. With early operation, fewer technical difficulties arise.

Technique of Reduction by Manipulation (Fig. 474)

A midline or right paramedian incision is made. Evisceration may be troublesome, and the incision should not be made any longer than necessary for adequate exposure. Because of the danger of further damage to the already damaged intestine, manipulation must be gentle. The intussusception is reduced by pressure from below. Ladd and Gross recommend passing the fingers into the abdomen to locate the head of the intussusception, which is then pushed backward along the colon. When reduced as far as the ascending colon or cecum, the entire remaining mass of the intussusception is delivered outside the abdomen. Here, under direct vision, the process of milking back or "taxis" is continued. Firm, slow compression of the bowel segment involved will reduce edema and squeeze out the invaginated part. Reduction of the terminal ileum at the cecum may be difficult. Traction on the intussusceptum must be avoided entirely or done with greatest care. Reduction may be aided by carefully stretching the receiving ring with a blunt instrument. Ladd and Gross believe that with persistence and patience 95 per cent of intussusceptions can be manually reduced. After complete reduction the bowel and mesentery must be carefully examined to determine its viability. The application of warm moist saline packs will aid in restoring circulation. Peristalsis or local contractions of the bowel are evidence of its viability.

To prevent recurrence, some surgeons recommend suturing the terminal ileum to the cecum or anchoring the mesentery. Ladd and Gross doubt the advisability of this procedure, stating that it is not always successful and that only 2 per cent of recurrences have occurred in their series without such precautions.

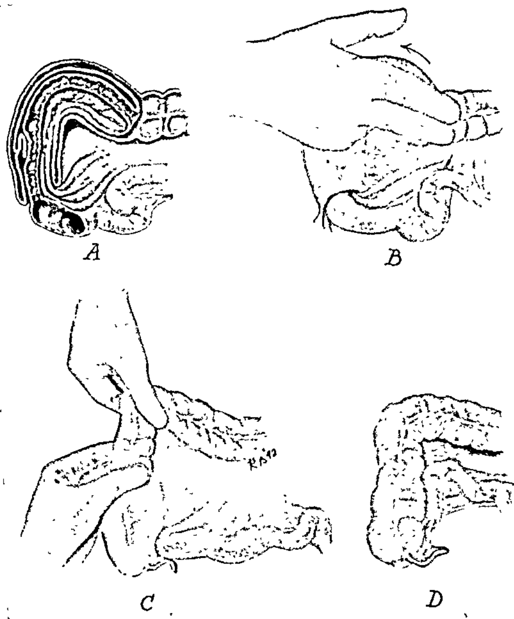


FIGURE 474. Technique of reduction of intussusception *A*, Common ileocolic type of intussusception. *B*, Stripping transverse colon is an early step in reduction. *C*, Manipulation and squeezing descending colon and cecum. *D*, Terminal ileum sutured to cecum to prevent recurrence.

Technique of Reduction by Resection

If reduction is impossible by the foregoing method or if gangrene demands a removal of a section of bowel, the involved portion may be exteriorized and cut away after the abdomen has been closed.

The distal and proximal spurs are sutured together before closure of the abdomen. A catheter can be sewed into the proximal segment of bowel to minimize soilage of the wound. Careful replacement of fluid and electrolyte loss is essential after operation. The spurs between the two loops can be crushed in two or three days, and full closure of the ileo-ileostomy or ileocolostomy is possible within a week or ten days.

Resection of the involved bowel with immediate end-to-end anastomosis has been proposed by some authors; Gross, however, recommends the exteriorization procedure because of lowered operating time, the minimization of shock, immediate decompression and lack of peritoneal contamination.

In the adult, resection and end-to-end anastomosis is the procedure of choice.

CONGENITAL ATRESIA OF INTESTINE

General Considerations

Congenital atresia may occur at any point in the small or large intestine. Rapid distention of the proximal intestine develops, and persistent vomiting with dehydration or perforation and peritonitis will result in death in a few days if the anomaly is not corrected by operation. The mortality rate of surgical therapy has been high. Early recognition and operation have reduced the mortality rate, as shown by the increasing number of successful results.

Technique of Operation (Fig. 475)

Congenital obstructions of the duodenum may be corrected by gastroenterostomy, duodenoduodenostomy or duodenojejunostomy. The two latter operations are preferable except in cases with obstructions near the pylorus.

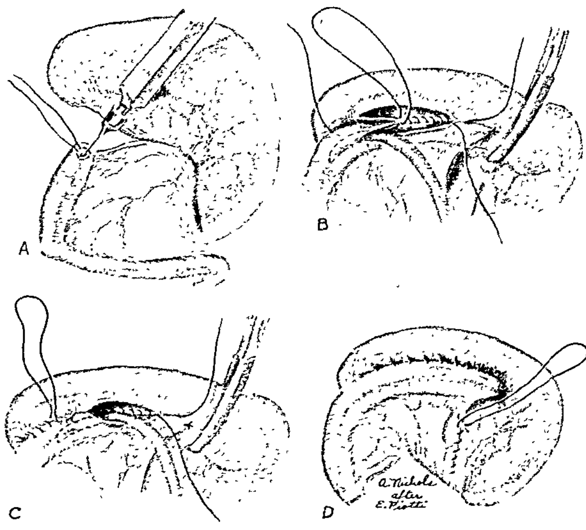


FIGURE 475. Technique of side-to-side anastomosis for atresia of the small intestine *A*, Dilated proximal and distal segments of the intestine The distal segment is distended with mineral oil and air. *B*, A rubber-shod clamp is placed on the proximal segment to prevent spillage. A continuous suture of fine silk or catgut is used to unite the seromuscular walls Fine catgut is used for the inner row of sutures A catheter is placed in the distal segment to prevent constriction of the bowel lumen when the stitches are placed *C*, The anterior margins of the opening are closed with a Connell suture of catgut. *D*, Anastomosis completed The mesentery is closed with a continuous suture. (Redrawn from Ladd and Gross· Abdominal Surgery of Infancy and Childhood.)

Atresia of the small or large intestine should be corrected by side-to-side anastomosis, although exteriorization of the two ends of bowel proximal and distal to the point of obstruction with subsequent crushing of the spurs may be used. The caliber of the bowel distal to the obstruction is too small for a successful end-to-end anastomosis, necessitating a side-to-side technique. The technique used by Ladd and Gross is recommended.

Operations upon the Appendix

General Considerations

The appendix is usually found in the right lower quadrant of the abdomen, but because of a congenital anomaly may be discovered in other parts of the abdomen. This fact must be kept in mind when considering obscure acute surgical diseases of the abdomen. The location of the appendix in the right lower quadrant varies widely. It may point in almost any direction from its attachment to the cecum. It is subject to many kinks and angulations due to adhesions. It may be entirely bound down by adhesions or entirely retrocecal or retroperitoneal.

The type of incision used to remove the appendix should depend upon the accuracy of the diagnosis and the location of the appendix. A right lower quadrant gridiron type of incision is the most satisfactory. If the diagnosis is in doubt and abdominal exploration is contemplated, a paramedian is preferable.

The appendix is located by exposing the cecum. The longitudinal bands converge at the cecal head and form the outer muscular coat of the appendix. If there is doubt about the location of the appendix after mobilizing the cecum, the ileocecal junction may be located and the appendix found below and lateral to this point. In acute appendicitis the appendix is often surrounded by adhesions and exudate, making it difficult to lift into the wound. By gentle exploration with the finger the appendix may be identified by palpation and freed until its base or tip is exposed.

Dangers and Safeguards

There is little danger in removing the appendix as long as the disease is confined to the appendix. The mortality rate rarely exceeds 1 per cent and is usually much lower. After an appendix has perforated, another disease process is active which increases the operative hazard.

Adequate exposure is necessary for visualization of the appendix. In a large majority of cases the cecum and appendix can be exposed through a relatively small wound, but if adherent deep within the abdomen, a large incision is often necessary. Attempting to remove an acutely inflamed or gangrenous appendix through an inadequate incision may result in its rupture, converting a clean into a contaminated wound.

The mesoappendix must be securely ligated to prevent hemorrhage from the appendiceal artery In a small percentage of cases inversion of the appendix stump may be difficult because of its location or because of extensive induration and edema of the cecal wall In such cases the appendix stump may be ligated and protected by omentum sutured to the cecum. Some surgeons consider it unwise to invert the ligated stump of the appendix, stating that an abscess may form about the stump, owing chiefly to necrosis of tissue distal to the ligature. To prevent this complication, the ligated appendix stump may be cauterized or treated with [illegible] alcohol, and covered by ome[illegible]

Lavage of the peritoneal cavity for the removal of infection is more likely to do harm than good. Washing and flushing the peritoneum breaks down nature's barriers to infection, spreads infection and increases absorption. Free pus should be evacuated by suction with a minimum of disturbance of the peritoneal surfaces.

When *drainage* is indicated, soft rubber drains of the cigarette type should be used. Drains should not be placed directly against the sutures in the cecum. Rubber tubing is undesirable as drainage material. Any rigid drainage material might result in erosion through the bowel wall or iliac vessels. If suppuration exists, the abdominal wound should be partially closed and well drained. Some authors advise that when a McBurney incision is used, the peritoneum should be sutured and the remainder of the wound left open and packed with petrolatum gauze to avoid extensive abdominal wall infection.

Operation for suppurative appendicitis may be followed in a few days by a fecal fistula. Such a fistula usually closes spontaneously. Surgical closure should be postponed for several weeks or months.

Technique of Appendectomy (Figs. 476, 477)

A McBurney incision is usually the choice. A right rectus incision is preferred if surgery in addition to appendectomy is contemplated.

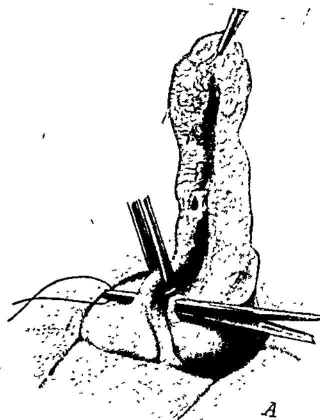
The cecum is located and rolled upward into the wound until the base of the appendix can be grasped with an Allis clamp placed about but not on the appendix. This is a useful method of applying traction without crushing the appendix. The mesoappendix is grasped near the tip of the appendix with a hemostat. Crushing a swollen and necrotic appendix may cause leakage and wound soiling.

With a pointed hemostat, an opening is made in the mesoappendix near the base of the appendix. Through this opening is passed a ligature of no. 0 chromic catgut, and the mesoappendix is ligated in one mass. When there is thickening of the mesoappendix due to infection and edema, it may be necessary to ligate this structure in two or more parts. This may also be advisable when the mesoappendix is short or contains much fat, or when the appendix is bound down by adhesions. The mesoappendix is cut between the ligature and the appendix.

When the appendix has been freed, it is carefully crushed at its base and ligated with fine plain catgut. A purse-string suture of no. 00 chromic catgut is placed in the cecal wall about the base of the appendix. The appendix is then divided between clamps with cautery or knife and the stump inverted while the purse-string suture is being tied. The ends of the tied purse-string suture are again tied over the stump of the mesoappendix. This approximates the stump of the mesoappendix and the cecum at the site of the inverted appendix stump.

The wound in the abdominal wall is closed in layers with fine chromic catgut. Silk or other nonabsorbable material is suitable for skin sutures.

If the appendix has perforated, with an accumulation of pus in the peritoneal cavity, drainage is advisable. After aspirating free exudate, a soft drain of the cigarette type or petrolatum gauze is placed down to the pelvic brim and brought out at the lower end of the incision. The wound should be only partially sutured and well drained. A cloudy exudate about an acutely inflamed or gangrenous appendix which has not perforated does not require drainage. A drain placed in the peritoneal cavity



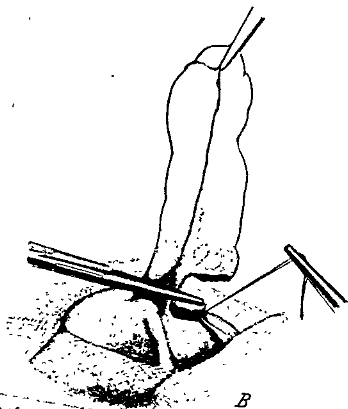


FIGURE 476 Technique of appendectomy *A*, Allis clamp used for traction on appendix to prevent crushing Tip of mesoappendix grasped with hemostat Ligature passed through mesoappendix near base of appendix. *B*, Mesoappendix ligated and base of appendix crushed

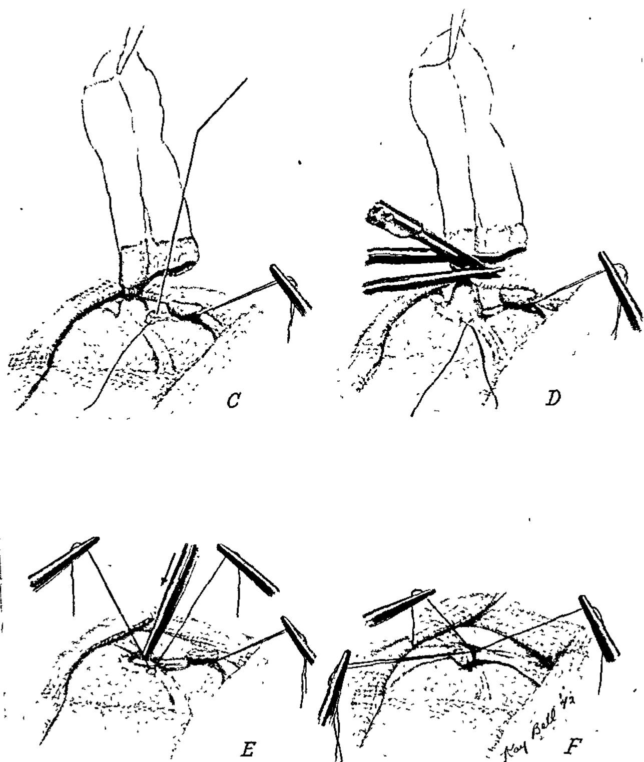


FIGURE 477. Technique of appendectomy (*continued*). *C*, Appendix ligated at site of crushing. *D*, Appendix divided between clamps. *E*, Stump of appendix buried with a purse string-suture. *F*, Ligated mesoappendix tied over inverted appendix stump.

will be walled off in a short time and act as a foreign body. Drains are of doubtful value after the third to fifth days unless placed to drain an abscess cavity.

Technique of Appendiceal Abscess Drainage

When possible, the incision should be placed directly over the abscess where the latter is in contact with the abdominal wall. The abscess may then be opened and drained without exposing the uninvolved peritoneum to infection. In many cases the abscess may be reached by making a short wound above the crest of the ileum. Pus should be evacuated by suction. Removal of the appendix involved in an abscess is usually not advisable unless it presents readily and can be cut away without breaking through the abscess wall. Appendectomy six to eight weeks later is safer. If the abcsess lies away from the abdominal wall, the free peritoneal cavity may be opened. A gauze pack placed down to the abscess, to be removed in five or six days, will form a channel for the exit of pus without contaminating the peritoneum. Careful blunt dissection will open such an abscess after the pack has been removed.

An appendiceal abscess may lie deep in the cul-de-sac and, when well developed, be drained by a stab wound made through the upper vaginal or rectal wall. Such cases must be carefully selected to avoid injury to the intestine.

A well developed abscess should be drained with two or three soft rubber tissue drains. One of them may be removed in forty-eight hours to increase the drainage about the others. All drains may usually be removed in five to seven days. If any infection develops in the abdominal wall, it should be promptly drained by removing sutures and spreading apart the wound margins.

Operations upon the Large Intestine

COLOSTOMY

General Considerations

Colostomy is most frequently indicated in the treatment of malignancies of the large bowel. Such a colostomy may be temporary or permanent, depending upon the operability of the malignant lesion, location of the lesion, and the extent of bowel resection necessary for the removal of the tumor. Colostomy is also indicated to produce physiologic rest of the colon incident to repair of benign lesions such as fistulas, congenital anomalies, strictures and diverticulitis.

The most common type of permanent colostomy is sigmoidostomy. The reason for this is obvious, since complete removal of the rectum does not permit reunion of the bowel. A temporary cecostomy or transverse colostomy is preferred by many surgeons as a means of decompressing an obstructed colon preliminary to a later resection.

The loop or double-barrelled and the end or single-barrelled colostomies are the types generally used. The Mikulicz temporary colostomy, designed to re-

establish the continuity of the bowel without opening the abdomen, may be used in certain types of colon resections.

Rankin emphasizes three features which he considers essential for a good sigmoid colostomy: (1) Take all slack out of the bowel so that it is pulled down from above as far as its mesenteric attachments will permit; (2) bring the bowel out through a small incision, usually a stab wound in the left lower abdomen; (3) bring the lumen of the bowel entirely outside the abdominal cavity. It is not essential that a permanent colostomy be made in the left lower abdomen when the rectum is resected. The umbilicus may be removed and its location used for the colostomy stoma as recommended by Hirschman, or the colostomy may be placed in the end of the midline incision as suggested by Tom Jones.

Dangers and Safeguards

The mortality rate incident to simple colostomy is usually low. As a palliative measure in advanced carcinoma of the rectum, Rankin has recorded a mortality rate of 7.67 per cent, but when done as a first-stage procedure of a combined abdominoperineal resection of the rectum, the death rate was but 2.7 per cent. The chief causes of death are peritonitis and pulmonary complications.

To minimize the danger of peritonitis, stitches should not be placed in the wall of the gut to attach it to the abdominal wall. Leakage may occur into the abdominal wound, producing severe infection. Stitches placed in the wall of a greatly distended bowel may readily produce a leak.

If a double-barrel or loop permanent colostomy is done, the loop protruding should be completely severed before the patient leaves the hospital so that fecal discharges will not be carried by peristalsis into the distal segment. In making such a colostomy, it is wise to suture the abdominal wall beneath the loop to provide separation of the two arms of the intestine after the wound has healed. The bowel, either in double- or single-barrelled colostomy, should protrude beyond the abdominal wall at least 2.5 cm. An opening, flush with the skin, frequently is constricted by scarring of the skin.

Attempts to add sphincteric action to a colostomy stoma have been discarded by most surgeons. All such efforts have proved inadequate and frequently prevent proper functioning of the colostomy. By giving a constipating diet and by daily lavage of the colon, the care of a colostomy will be reduced to a minimum. A simple absorbent pad dressing is frequently all that is necessary. Rubber bags are efficient, but often bulky, and develop a foul odor. Frequent changing of rubber receptacles and cleansing in deodorant solutions may be satisfactory to some patients.

If the opening in the abdominal wall is too large, a hernia may develop or prolapse of the bowel may result.

Technique of Loop Colostomy (Fig. 478)

A segment of transverse colon, usually on the right side, is most satisfactory for the relief of obstructive lesions of the left colon and rectum. Either a transverse or a vertical incision is suitable. An incision is made through the abdominal wall large enough to freely withdraw the loop of colon. If an exploratory incision has been made, the loop may be placed in such an incision. A portion of bowel is selected and a small

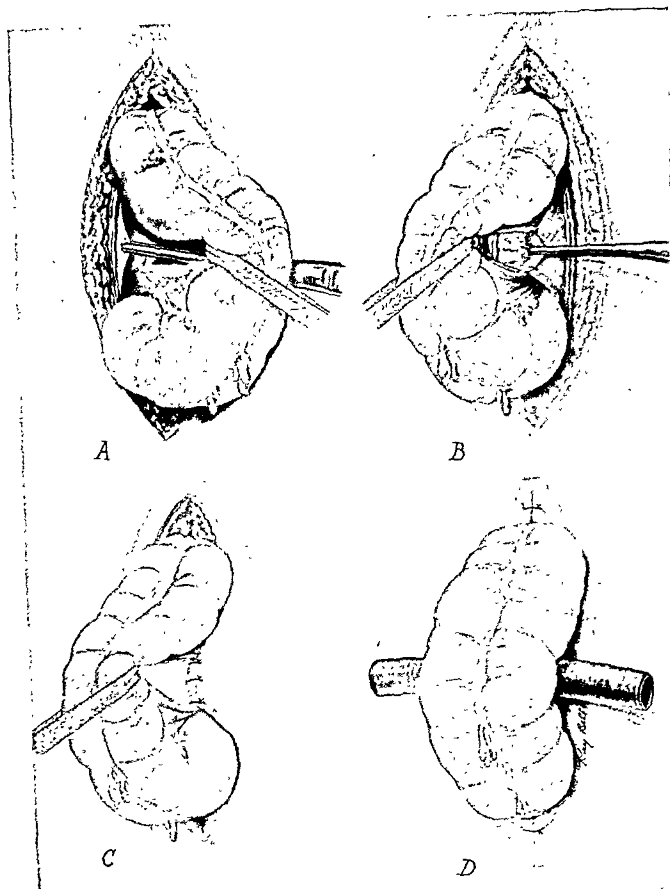


FIGURE 478. Loop colostomy. *A*, Loop of colon delivered and held with tape. *B*, Posterior rectus fascia sutured beneath loop. *C*, Skin closed beneath loop. *D*, Wound closed and rubber tube placed beneath loop.

opening made in its mesentery near the bowel wall. Through this opening is passed a tape or rubber tube for traction. If a sigmoid colostomy is made through a wound at the margin of the left rectus muscle, is is safer to close the opening between the bowel and left abdominal wall with a purse-string or a few interrupted sutures in the peritoneum to prevent intestinal obstruction. The peritoneum is closed beneath the loop with two or three sutures. The anterior fascia and skin are likewise sutured beneath the loop in the same manner. The closure of the wound is completed with similar interrupted sutures placed above and below the loop. The bowel lumen should not be constricted. A rubber tube or glass rod is placed beneath the loop to prevent retraction.

The wound is dressed by placing strips of petrolatum gauze about and over the protruding loop. After forty-eight to seventy-two hours a small incision is made in the loop to relieve obstruction. If desired, a small rubber tube or catheter may be placed in the proximal gut and fixed temporarily with a purse-string suture. After the wound has healed, the gut is completely sectioned with a cautery. If too redundant, the protruding portions may be removed with the cautery, leaving at least 2.5 cm. of the bowel protruding.

Technique of Closure of Colostomy

If the colon has been completely severed after a loop colostomy, or if a segment of the colon has been removed, an end-to-end anastomosis is done when closure of the colostomy is indicated.

An incision is made of sufficient length to mobilize the two ends of the colon within the abdomen. The colon is completely separated from the abdominal wall. The margins of the bowel openings are cut away to remove scar tissue. All fatty tissue is dissected from the ends of the bowel so that serosal surfaces may be carefully approximated. An end-to-end anastomosis is made, using fine chromic catgut for the inner row of sutures and interrupted Lembert sutures of fine silk for the outer row. The fascial layers of the abdominal wall are dissected free and closed separately with chromic catgut or silk.

Technique of Wangensteen Colostomy for Fecal Diversion (Figs. 479, 480)

A transverse incision 10 to 12 cm. long is made through all layers of the abdominal wall directly over the right transverse colon. A loop of colon is withdrawn from the wound, and the omentum is freed from the loop to be exteriorized. Two glass rods are placed beneath the colon to ensure exteriorization of the bowel segment above the skin level. To fix the loop of colon in the wound, the peritoneum and posterior rectus sheath, the anterior rectus sheath and the skin are sutured to fatty tags on the colon with interrupted sutures of fine silk (no. 0000). If the bowel is distended, it is deflated with an aspirating needle. The aspiration may be repeated in six hours if necessary. When the colon is obstructed, it is drained with a catheter inserted into a small opening made proximal to the most proximally placed glass rod. The glass rods are held apart beneath the bowel by a loop of rubber tubing fixed to the abdominal wall with strips of adhesive. This places the orifices of the bowel at opposite ends of the incision when the anterior bowel wall is opened. From three to five days after the operation the colon is opened in the axis of the bowel a distance of 3 to 3.5 cm., and later the

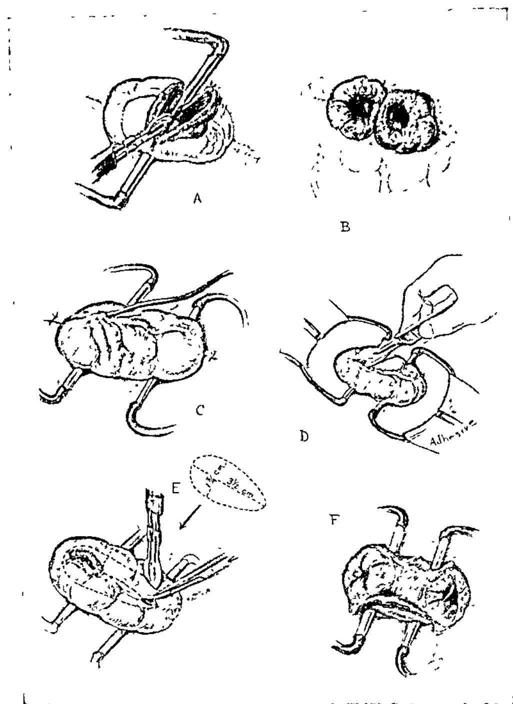


FIGURE 479 Technique of Wangensteen loop colostomy for complete fecal diversion *A*, *B*, Conventional method of making a loop colostomy The proximal and distal openings are too close together to completely divert the fecal stream *C*, The exteriorized colon is shown held in place with 2 glass rods. When distended, the colon is first aspirated and then drained with a catheter sutured in a stab wound. *D*, Method of holding loop of bowel with glass rods, rubber tubing and adhesive straps A linear incision is made in the bowel proximal to the proximal rod 3 to 5 days after operation. *E*, A few days later the bowel is unroofed about the orifice *F*, Completed colostomy. The mucosa everts and becomes adherent to the skin (Wangensteen: Surg., Gynec & Obst, Vol. 84. By permission of Surgery, Gynecology and Obstetrics)

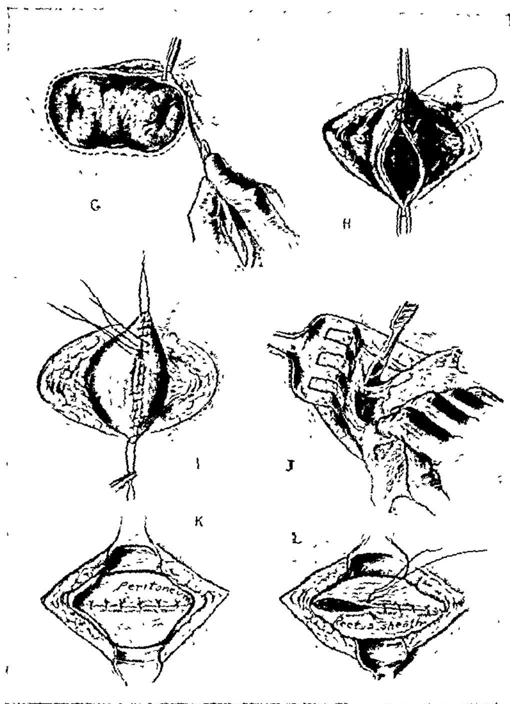


FIGURE 480 Technique of Wangensteen loop colostomy for complete fecal diversion (*concluded*) *G*, An incision is made in the skin 2 to 3 mm from the mucosal edge *H*, The bowel is closed transversely with a continuous suture of fine chromic catgut *I*, The gut is freed adequately, and a second row of interrupted sutures of silk inverts the first row of sutures. *J*, The bowel is dissected free completely so it may be returned to the peritoneal cavity. *K*, Suture of posterior rectus sheath and peritoneum with interrupted sutures of silk. *L*, Closure of anterior rectus with no. 000 silk sutures (Wangensteen: Surg , Gynec. & Obst , Vol. 84 By permission of Surgery, Gynecology and Obstetrics)

orifice is excised by cutting away an elliptical section of the anterior wall. Cutting away too much bowel wall will interfere with subsequent closure. When healed, the colostomy opening usually measures about 3 cm. in width and 5 cm. in length. A colostomy of this type will completely divert the contents of the colon.

The colostomy is closed transversely. The skin about the opening is incised about 2 mm. from the bowel. The bowel margin, with skin edge, is closed with a continuous suture of no. 000 chromic catgut. To minimize the danger of infection, surgeons now change their gowns and gloves and again drape the wound margins. The bowel is separated completely from the peritoneum. A row of interrupted silk sutures completes the closure of the bowel. The abdominal wound is closed in layers with interrupted sutures of silk. The wound is thoroughly washed with saline solution after closure of each layer.

Technique of Devine Colostomy (Fig. 481)

This operation has been designed to "defunction" and "debacterialize" the distal colon. By this procedure the content of the proximal colon is prevented from entering the left half of the colon, which is rested and cleansed preparatory to resection. This type of colostomy is suitable for both benign and malignant lesions of the distal colon that may require resection. By thorough preparation of the "defunctioned" bowel, many operations are made much safer and easier to perform. In malignant disease the bowel should not be "defunctioned" for more than a month, but in benign conditions operations upon the left half of the colon may be postponed indefinitely as long as there is hope of local improvement. Following his "defunctioning" colostomy, Devine has successfully resected segments of the left colon with primary suture, excised the rectosigmoid with primary suture of the sigmoid to a short rectal stump, and has united the bowel by secondary suture after an inguinal colostomy of several months' duration.

An upper right rectus incision is made about 7 to 8 cm. long. The incision must be long enough to admit the hand for a thorough abdominal exploration. If the transverse colon is long, its proximal portion is withdrawn from the abdomen, and a rubber tube or tape is passed through the apex of the loop. The loop is stretched to its fullest extent and its sides united a distance of 10 to 12 cm. with two rows of continuous chromic catgut sutures to form a spur. If the transverse colon is short, a long spur is made by suturing the proximal part of the transverse colon to the ascending colon with the apex of the loop at the hepatic flexure.

The parietal peritoneum is sutured around the neck of the loop. Buttonhole openings are made through the skin and subcutaneous tissues 2.5 cm. to each side of the primary incision. Ochsner clamps are passed through the small openings in the skin, and the bowel wall is grasped at the apex of the loop from each side. The loop is divided with a cautery, and the cut sides are coagulated down to the surfaces of the clamps. The severed ends are then drawn through the small lateral incisions, and the skin edges are sutured to make a pair of small fistulas.

The primary wound is closed and sealed with a collodion dressing. The clamps are left attached to the ends of the severed bowel. The proximal clamp may be removed in twelve hours, and the distal clamp may be left in place for several days.

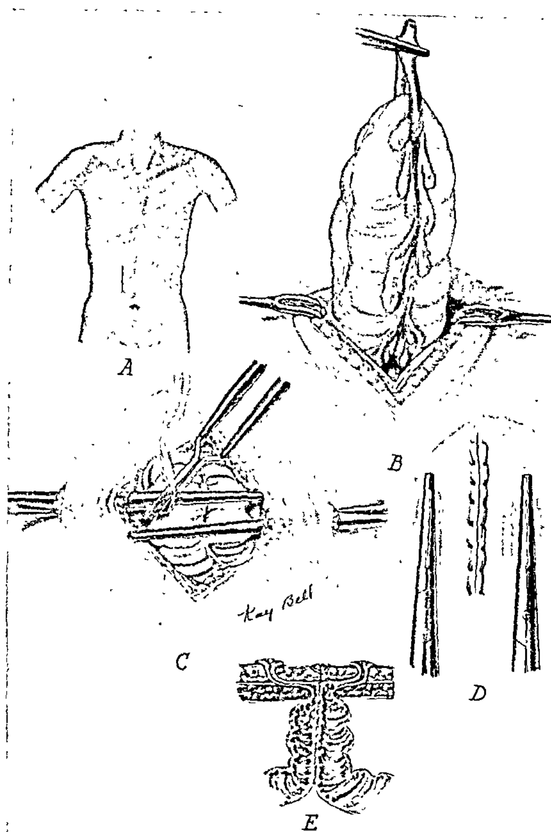


FIGURE 481 Devine colostomy *A*, Upper right transrectus incision for transverse colostomy. *B*, Colon delivered and proximal and distal segments sutured together *C*, Clamps passed through lateral stab wounds grasping gut Gut divided with cautery *D*, Primary wound closed. Clamps on protruding ends of severed bowel *E*, Section showing appearance of proximal and distal segments after completion of operation

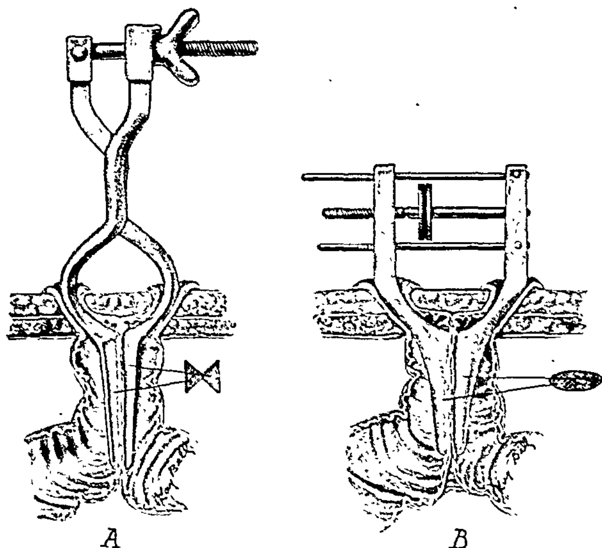


FIGURE 482. Technique of Devine colostomy *A*, Devine enterotome applied. *B*, The DeBakey-Ochsner enterotome applied

After the distal colon has been decompressed and cleaned by irrigations and the operative procedure has been completed, the colostomy spur is crushed with the Devine enterotome (Fig. 482) or with the clamp designed by DeBakey and Ochsner (Fig. 482). After complete healing following resection of the distal colon, the two small colostomy openings may be closed. If the protruding mucosa is cauterized down to the skin level, these openings may close without operation.

CECOSTOMY

Technique (Hendon) (Fig. 483)

A McBurney incision is made. The cecum is identified and lifted into the wound when possible. A purse-string suture is placed through the seromuscular coat at or near the presenting longitudinal band. A second purse-string suture is placed about the first at a distance of 1 cm. A stab wound is made within the circle of the first purse string, and a size no. 28 or 30 French mushroom catheter is inserted. The first

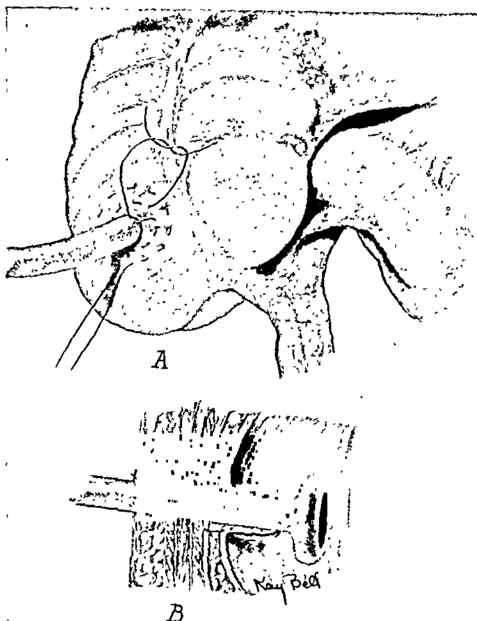


FIGURE 483. Hendon cecostomy. *A*, Large mushroom catheter in cecum with purse-string sutures ready for fixation. *B*, Section of abdominal wall and cecum shown. Mushroom catheter in place.

purse string is tied snugly about the catheter and fixed by passing the needle through the wall of the catheter and tying. This suture is cut away and the cecal wall invaginated by pushing inward on the catheter. The second purse string is then tied and fixed to the catheter wall in the same manner as the first.

The cecal wall near the catheter is sutured to the peritoneum to approximate the cecum to the abdominal wall. The wound is closed about the catheter, and a fixation suture of fine silk is passed through the skin and catheter wall to prevent accidental withdrawal. When ready to remove the catheter, it is severed near the skin, and the distal portion is pushed into the cecum to be discharged through the bowel. As a result of invagination of the cecal wall, the opening will usually close spontaneously.

A Witzel type of enterostomy may be used if the surgeon prefers. The Witzel technique is described elsewhere. A cecostomy may be made by suturing the cecal wall to the skin. This type affords good drainage, but requires later closure by operation.

COLECTOMY

General Considerations

The chief indications for complete colectomy are general polyposis of the colon and selected cases of ulcerative colitis. In some cases of polyposis it is possible to remove the polyps from the rectum and later follow with ileosigmoidostomy and subtotal colectomy. In extensive ulcerative colitis, removal of the entire colon and rectum with the establishment of ileostomy is the treatment of choice. In selected cases this may be accomplished in one stage; however, two or three stages may be necessary. In rare cases in which there is no ulceration in the rectum the rectum may be left in place, or the terminal ileum may be anastomosed to the rectum as a third-stage procedure.

Dangers and Safeguards

The danger of colectomy for polyposis is not so great as for ulcerative colitis. The chief danger of operation for ulcerative colitis is the generally poor condition of the patient. Fever, anemia, dehydration, hypoproteinemia, emaciation and exhaustion are often present. The colitis may be complicated by pericolonic abscesses, which may rupture during the manipulation of operation. The thickened friable mesentery will, at times, make ligation of the mesenteric vessels difficult. Rectal complications, such as strictures, perirectal abscesses and fistulas, increase the danger of infection.

Colectomy should not be considered until the patient has shown maximum improvement with medical care. If the hemoglobin is low, transfusions should be given until the hemoglobin is 70 per cent or above. If hypoproteinemia exists, it should be treated preoperatively with a high protein diet and transfusions. Infusions of 5 per cent dextrose solution should be given to relieve dehydration. To this should be added vitamin B complex and vitamin C. Adrenocorticosteroids have been effective in improving the general nutritional status of these patients. The intestinal antimicrobial agents are also of value in reducing the degree of intestinal sepsis. Transfusions of blood and infusions of 5 per cent dextrose should be administered during and after operation.

Ileostomy is accompanied by a loss of body fluid with a loss of body weight. There is also a change in body chemistry due to loss of chlorides and dehydration. Drainage from an ileostomy is irritating to the skin and must be guarded against by adequate protection of the area about the opening. After removal of the colon the terminal ileum gradually assumes, in part, the function of the colon, and, in time, the patient can control the discharges with comparative comfort. Prolapse of the ileum may occur if the mesentery is not adequately fixed to the peritoneum when the ileostomy is made.

In properly selected cases colectomy may be done with a mortality rate which compares favorably with the mortality rate incident to other major operations upon the colon and rectum.

Technique of Colectomy

Removal of the entire colon and rectum as a one-stage procedure as recommended by Ravitch, Fallis and others has evolved as the procedure of choice whenever possible, and improvements in supportive treatment have made the one-stage

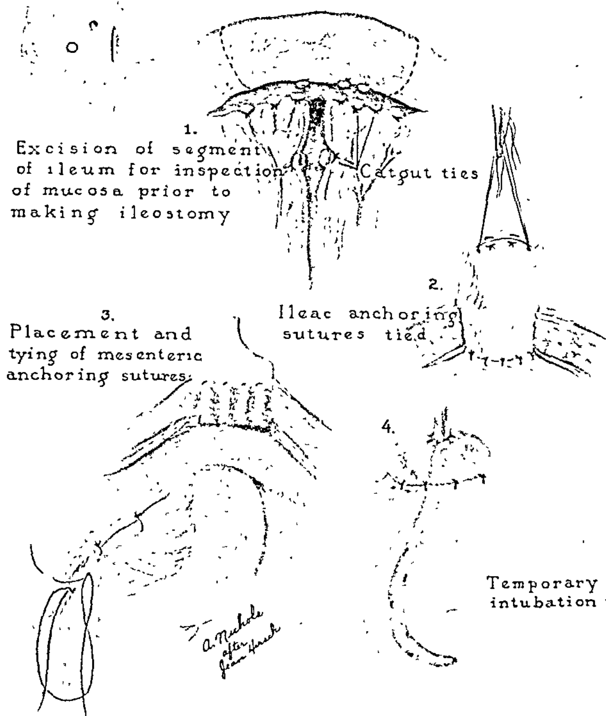


FIGURE 484 Technique of ileostomy as first stage of colectomy for ulcerative colitis Inset shows sites of left rectus incision and circular skin incision for ileostomy *1*, Section of terminal ileum freed for excision and inspection for disease *2*, Proximal end of severed ileum closed and held with traction sutures Posterior rectus sheath and peritoneum sutured to wall of ileum *3*, Mesentery of proximal end of ileum anchored to the peritoneum *4*, Completed ileostomy with drainage tube. The skin has been sutured to the ileum about 1 5 cm distal to the point on the bowel where it would lie naturally (*Redrawn from Dennis Surgery, Vol 18*)

operation possible in an increasing number of cases. It may be necessary, however, to stage the operation in one, two or three separate procedures. The operative technique of Dennis is here followed, keeping in mind that the stages may be combined.

First Stage. Local anesthesia is considered safer than inhalation anesthesia. An incision 8 cm. long is made through the lower portion of the left rectus muscle. Manipulation of the colon is avoided. The ileum is identified and examined for evidence of

disease in its terminal portion, which is involved in 20 to 30 per cent of the cases. The ileostomy must be made above the level of the disease. The site of section of the ileum is chosen, and its mesentery is infiltrated with local anesthetic and divided a distance of 8 to 10 cm. towards its root (Fig. 484).

A segment (1) of the ileum is removed between clamps, and the proximal and distal ends are closed with two rows of sutures. The distal stump of the ileum is turned down and sutured to the mesentery to prevent intussusception. The sutures are left long on the proximal end for future use. If the resected segment of the ileum shows evidence of disease, an additional portion of the ileum is removed.

At a site 6 cm. below the level of the umbilicus and 3 cm. to the right of the midline a circular defect is cut in the skin two thirds of the diameter of the ileum to be passed through it. The opening is made in the skin so that the cuticular layer projects farther toward the center of the circle than the deeper layers of the dermis. The cuticular layer may be extended upward on the ileum when sutured to improve healing.

Through the circular opening an incision is made in the rectus sheaths and muscle just large enough for the passage of the ileum. The proximal ileum is drawn through the opening in the abdominal wall, and the ileum and mesentery are sutured to the peritoneum and posterior rectus sheath (2). Very fine silk sutures are used which do not penetrate the lumen of the bowel.

To prevent prolapse of the ileum, its mesentery is carefully sutured to the peritoneum. The protruding ileum is pushed downward into the subcutaneous tissues, and the skin is elevated and sutured to the wall of the bowel with fine chromic catgut (4). Such a maneuver prevents retraction of the ileum and leaves the skin flat about the bowel for snug fitting of the ileostomy bag. At least 3 cm. of the ileum should protrude above the skin.

The left rectus incision is closed in layers with interrupted silk sutures.

A catheter is placed in the ileum, and light suction is applied. An indwelling Wangensteen gastric tube is used for forty-eight hours. The catheter is removed at the end of four days. After seven days a Koenig-Rutzen ileostomy bag is fitted.

Dragstedt and his associates have suggested that the ileum protruding through the abdominal wall be grafted with a split skin graft cut with the Padgett dermatome. The ileum should protrude 10 to 12 cm. so that it may drain into a receptacle to avoid excoriation of the skin.

In patients with stricture or obstruction of the colon a loop ileostomy should be made or the ileum should be divided and the distal end implanted in an opening made in the abdominal wall lateral to the right rectus muscle as suggested by Cattell.

Second Stage. In five or six months following ileostomy the general condition of the patient usually improves so that colectomy may be done with minimum risk.

In the second stage the terminal ileum and colon down to the lower sigmoid are removed. Suction through a Miller-Abbott tube (as suggested by McKittrick and Cave) for forty-eight hours before operation will contract and shorten the small bowel until it occupies a minimum space in the abdomen

Spinal anesthesia, supplemented when necessary by intravenous or inhalation anesthesia, is satisfactory. A long left paramedian incision is made from the level of the xiphoid process to a midpoint between the umbilicus and pubes.

If the distal segment of the ileum is open, it is detached from the abdominal wall

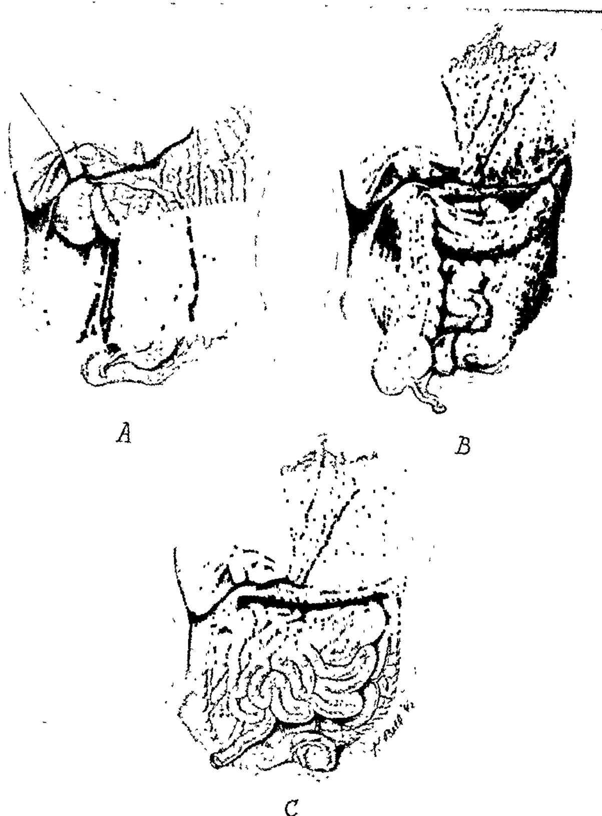


FIGURE 485. Colectomy *A*, Mobilization of cecum and right half of colon The parietal attachment of the bowel is divided, and dissection is made from without inward *B*, Colon is mobilized with preservation of the omentum *C*, Colon removed down to midsigmoid. Distal end of sigmoid inverted with sutures. Rectum and sigmoid to be removed at a later stage if necessary Peritoneum closed with continuous suture. (Redrawn from Rankin, Bargen and Buie The Colon, Rectum and Anus)

and closed with a rubber dam or rubber glove tied over the open end. The terminal ileum, cecum and ascending colon are mobilized medialward after dividing the lateral parietal peritoneum along its reflection from the gut. Injury to the duodenum and ureter must be avoided. The blood vessels in the mesentery are divided and ligated as close to the bowel as the disease will permit so that the peritoneum may be closed later. Rankin has recommended preservation of the omentum, but Cave and Cattell believe it inadvisable. The mesentery of the transverse colon is cut and ligated. Mobilization of the splenic flexure is usually more difficult than other parts of the colon. The splenocolic ligament is divided, and all its vessels are clamped and ligated.

The descending colon and upper sigmoid are reflected medialward after dividing the peritoneum near the bowel. The mesenteric vessels are ligated near the bowel down to the superior hemorrhoidals. After carefully controlling all bleeding, the peritoneum is closed over the cut margin of the mesentery throughout its length (Fig. 485). At a point above the rectosigmoid junction the bowel is divided between clamps with a cautery, and the freed colon is removed. It is sometimes difficult to prevent wound soiling, since the bowel wall is frequently very friable. The lower end of the sigmoid is closed with two or three rows of sutures. If it is impossible to close the sigmoid, it may be wrapped in gauze and brought out at the lower end of the abdominal incision pending the third stage of the operation. Dennis recommends invagination of the end of the lower sigmoid. The sigmoid is freed by reflecting the peritoneum from each side and is divided between ligatures. The superior hemorrhoidal vessels are carefully preserved. To invaginate the end of the sigmoid, a brass tube with a wooden core is introduced into the rectum, and into the wooden core needles threaded with a loop of steel wire are inserted from the abdomen so that the wire when drawn downward will cross the ligature about the bowel. The wooden core is withdrawn from the anus, and by making traction on the wire the end of the sigmoid is invaginated and held while the end is reinforced with two rows of sutures. By a sawing motion of the steel wire, the ligature about the end of the turned-in sigmoid is severed to open the bowel end to avoid the formation of a dead space for infection to develop. The peritoneum is then closed over the invaginated sigmoid and rectum, excluding them from the peritoneal cavity.

Third Stage. Several months later, if the disease in the rectum is still producing symptoms, the rectum and lower sigmoid are removed by the combined abdomino-perineal resection as described for carcinoma of the rectum. Freeing of the rectum is usually not difficult, since it is not necessary to sacrifice tissues adjacent to the rectum as in the removal of carcinoma.

If the rectal segment is producing little or no discomfort to the patient, the third stage of the operation may be abandoned. When the rectum shows no evidence of ulceration, an ileoproctostomy may be done after the terminal ileum has developed some of the functions of the colon

RESECTION OF THE COLON

General Considerations

During the past decade there have been several technical advances in excisional surgery of the colon. In addition to vast improvements in preoperative and postopera-

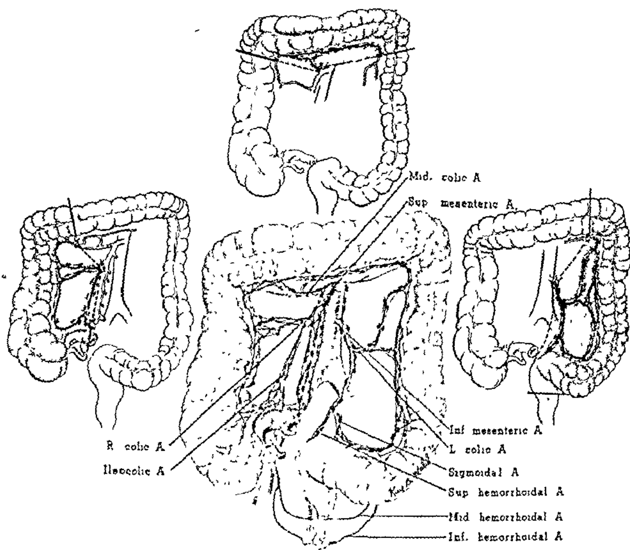


FIGURE 486 Diagram showing the most common blood supply and lymphatic distribution of the colon Also shown is the ideal extent of excision for lesions of the right colon, transverse colon and left colon

tive supportive treatment of all surgical patients, as well as advances in techniques of anesthesia, better preoperative preparation of the colon by mechanical cleansing and use of the intestinal antimicrobial agents has diminished greatly the hazards of sepsis following colon resection whatever the indication may be. Primary end-to-end anastomosis is now almost universally used as the method of choice when obstruction is not present, in which case preliminary diverting colostomy is indicated. Staged resections and resections by the Rankin obstructive method are used rarely. In resections of the colon for carcinoma there has been a tendency toward removal of wider segments of bowel along with more of the draining lymphatic and vascular channels and lymph nodes. Most of the colon can be excised without serious postoperative consequences, so that certain authors have urged even wider resections than those now recommended to permit even wider removal of the area lymphatics and nodes Figure 486 shows the blood supply and lymphatic distribution to the colon, as well as the recommended limits of excision for lesions in the various segments.

It should be pointed out that there are frequent variations in the vascular pattern of the colon. In addition to wider resection, an important factor in the long-term survival rates following colon resection for carcinoma is the prevention of the dis-

semination and implantation of cancer cells during the operative procedure. In addition to the use of large incisions and gentle handling of the tumor during abdominal exploration, preliminary ligation of the vascular channels to be removed, as well as occlusion of the bowel proximal and distal to the lesion with umbilical tape as advocated by Cole and others before mobilization of the tumor and segment of bowel to be removed, is an important technical point in the prevention of dissemination of cancer cells and implantation of cells in the anastomosis line. Generous lavage of the bowel lumen before performing the anastomosis has also been advocated.

Thorough understanding and application of the principles enumerated above by those doing colon surgery, as well as improved diagnostic methods, can produce a high percentage of cures of cancer of the colon.

RESECTION OF THE CECUM AND ASCENDING COLON

General Considerations

It is usually desirable to resect the terminal ileum, cecum, ascending colon, hepatic flexure and a portion of the transverse colon for malignant lesions involving the cecum and ascending colon. The intestinal tract is re-established by anastomosing the terminal ileum to the transverse colon.

Before operation the bowel is prepared by means of catharsis and irrigation, and the bacterial content is reduced by the use of antimicrobial agents. A nonresidue diet is prescribed for several days before operation. Passage of an intestinal decompression tube simplifies retraction of the small bowel during operation and prevents distention and undue tension on the suture lines during the postoperative period.

Technique of Right Colectomy (Figs. 487, 488, 489)

A right transrectus, paramedian or oblique incision is satisfactory, although it should be so placed and of such length as to permit adequate exploration and manipulation of the bowel without undue pulling and tugging. The local growth is examined carefully, and regional lymph nodes and liver are explored for metastases.

Before mobilizing the colon, the right colic artery and vein, the ileocolic artery and vein and the right branch of the middle colic artery and vein are isolated, ligated and divided. Next, the bowel distal and proximal to the lesion is occluded with umbilical tape. The peritoneal attachment of the cecum, ascending colon and hepatic flexure is divided along the right margin of the bowel, thus permitting the entire right colon to be rotated toward the midline with little bleeding. The retroperitoneal fat and lymphatics are freed with the bowel toward the root of the mesentery. This maneuver exposes the spermatic vessels and ureter in the lower part of the wound and the kidney and duodenum in the upper portion after freeing the hepatic flexure. These structures should be carefully protected from injury. The entire segment of colon to be removed is lifted outside the abdominal cavity and is walled off with moist laparotomy tapes. The ileum is then divided obliquely approximately 15 cm. from the ileocecal valve, making certain that adequate blood supply to the remaining bowel is available. The transverse colon is then divided between clamps near the junction of the right and middle thirds and the specimen removed.

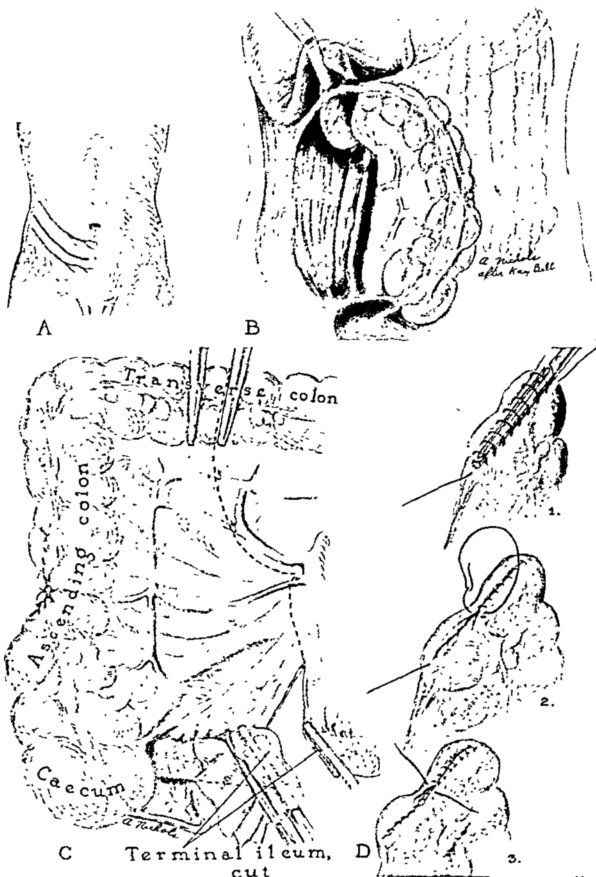


FIGURE 487 Technique of resection of right colon *A*, Location of oblique abdominal incision. *B*, Mobilization of right colon with exposure of kidney and ureter. *C*, Lines of incision through colon, mesentery and terminal ileum. *D*, *1*, *2*, *3*, Method of closure of cut end of transverse colon if end-to-side anastomosis is to be used.



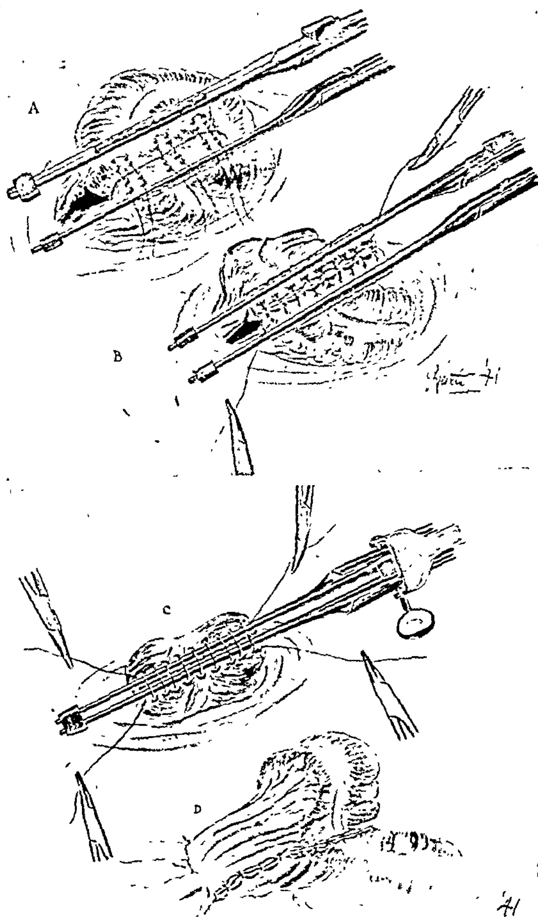
FIGURE 488. Technique of resection of right colon (*continued*). Completed operation, showing end-to-end anastomosis between the ileum and colon. Closure of the rent in the mesentery is essential to prevent herniation of a loop of small intestine through this defect. The defect in the posterior parietal peritoneum along the right abdominal gutter is not closed.

Intestinal continuity is then re-established by anastomosing the terminal ileum to the transverse colon. In most cases this can be accomplished in an end-to-end fashion, although it may be preferable to close the end of the colon and anastomose the end of the ileum to the side of the transverse colon. The open type of anastomosis, using an inner layer of continuous catgut sutures and an outer layer of interrupted silk, is the one most widely used. However, the closed technique or the single layer silk technique of anastomosis is acceptable. The mesentery of the ileum and of the transverse colon is then approximated to prevent herniation of bowel through this space. In most instances reperitonealization of the right abdominal gutter is not feasible. The abdomen is closed in layers without drainage.

RESECTION OF THE TRANSVERSE COLON

Preoperative preparation is carried out as outlined for resections of the right colon. If an obstruction exists, preliminary cecostomy or colostomy must be done to decompress the colon before the resection is attempted.

Either an upper transverse incision or a paramedian incision is suitable, depending upon the preference of the surgeon and habitus of the patient. The abdomen is carefully explored for metastases. Resection is indicated in selected cases with metastases to prevent obstruction and continued bleeding and to prolong life. Since the lymphatic drainage of this segment of bowel follows closely the distribution of the middle colic artery and vein, these vessels are first isolated, ligated and divided near their origin. If the lesion lies at the hepatic flexure, removal of the entire right colon along with the transverse colon is indicated; indeed, some authors prefer this technique for all lesions of the transverse colon, since re-establishemnt of intestinal continuity by


A
B
C
D

anastomosing the ileum to the descending colon is preferable in many instances to reanastomosing the two segments of colon. When the lesion lies in the left portion of the transverse colon or splenic flexure, the left colic artery along with the portion of the descending colon supplied by this vessel and the mesentery should be removed.

When the vascular channels of the area to be excised have been divided, the gastrocolic ligament is divided near the greater curvature of the stomach and ligated. Both the hepatic and splenic flexures are next mobilized by incising their attachments to the lateral abdominal wall. The entire greater omentum is removed with the specimen. The entire segment of bowel to be removed is thus mobilized into the wound and the V-shaped segment of mesentery down to the vascular pedicle divided. It will be necessary to clamp and ligate a few small vessels. The proximal and distal limits of the segment to be excised are then determined by assessing the blood supply to the portion of bowel to remain, and clamps are placed across the bowel at the selected points. It is important to clean the surrounding fat and areolar tissue from the bowel so that a clean margin of bowel wall will be available for the placement of sutures. If the entire right colon has been removed, intestinal continuity is re-established by uniting the ileum to the remaining portion of colon as described for right colectomy. Otherwise the two portions of colon remaining are anastomosed. The anastomosis can be made using either the open or closed method as preferred. Techniques of end-to-end aseptic anastomosis are illustrated in Figures 490, 491 and 492. The abdomen is closed without drainage.

RESECTION OF THE DESCENDING COLON AND SIGMOID

The ideal operation for carcinoma arising in the descending colon or sigmoid is left hemicolectomy, that is, resection of the left colon with its entire lymph-node-containing mesentery from the splenic flexure to the rectum with ligation of the inferior mesentery artery at its origin from the aorta. In certain cases when the lesion lies in the lower sigmoid or rectosigmoid, it may be preferable to ligate the inferior mesenteric vessels just distal to the origin of the left colic artery, leaving the descending colon to be anastomosed to the upper rectum.

Preoperative preparation is carried out as for resections of the colon in general. Either a long left oblique incision or left paramedian incision is suitable. After abdominal exploration the extent of excision is determined. If a left hemicolectomy is to be done, the posterior peritoneum is opened near the ligament of Treitz and the inferior mesenteric vessels isolated, ligated and divided. This permits dissection of the lym-

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FIGURE 492 Wangensteen technique of aseptic (closed) oblique end-to-end anastomosis. *A*, Three or 4 Halsted mattress sutures of silk are placed as the posterior row. Interrupted sutures are placed between the mattress sutures This outer row of sutures should not lie more than 5 to 7.5 mm from the clamps *B*, The inner posterior row is made with a continuous suture of no 000 catgut The ferrules are removed, and the clamps are rotated for placement of the anterior row of sutures *C*, The double ferrule has been placed over the tips of both clamps, and the locking device has been fastened over the midportion to hold the clamps in apposition A continuous suture of catgut is placed over the blades anteriorly *D*, The clamps are withdrawn and the ends of the catgut sutures drawn taut and tied together An anterior row of interrupted Halsted sutures of fine silk completes the anastomosis (From Wangensteen Intestinal Obstruction Courtesy of Charles C Thomas, Publisher.)

phatic channels and nodes from above downward along the abdominal aorta. The lateral attachment of the colon and sigmoid are then divided, permitting the entire left colon to be mobilized toward the midline.

Care must be taken to avoid injury to the ureters. The splenic flexure must be mobilized downward, taking care not to injure the spleen and tail of the pancreas. The bowel is then divided between clamps proximally in the region of the distal transverse colon and distally in the region of the rectosigmoid and a V-shaped portion of the mesentery based at the origin of the inferior mesenteric artery removed. Bleeding points in the divided mesentery are clamped and ligated. Intestinal continuity is then re-established by completing an end-to-end anastomosis between the remaining portions of bowel. The adjoining mesentery is approximated with interrupted sutures. The abdomen is then closed without drainage.

TECHNIQUE OF THE RANKIN OBSTRUCTIVE RESECTION (FIG. 493)

This procedure is now indicated only rarely when conditions make primary resection and anastomosis impossible.

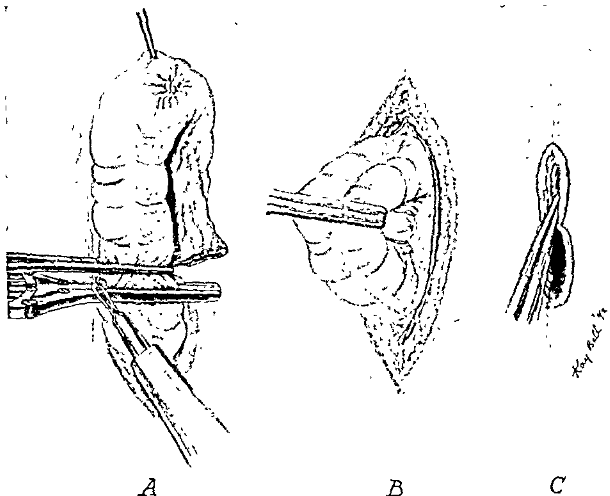


FIGURE 493 Rankin obstructive resection of the colon *A*, Segment of colon delivered, crushed with Rankin clamp and removed with cautery *B*, Posterior rectus sheath united with suture beneath clamped bowel. *C*, Two clamps applied to cut out the spur by necrosis between the proximal and distal segments (Redrawn from Rankin, Bargen and Buie· The Colon, Rectum and Anus.)

A paramedian incision is made of sufficient length to permit adequate visualization of the part to be resected. As in all colon surgery, careful attention must be given to the preservation of the blood supply to segments of bowel to be united later.

The section to be removed is mobilized, and the lymph-node-bearing area of mesentery is divided at its root. The Rankin three-bladed clamp (or two crushing clamps) is applied to the two arms of the freed colon with the handles toward the abdominal midline so that the clamp may rest on the abdominal wall. Other clamps are applied to the isolated loop distal to the Rankin clamp. The bowel is divided with a cautery between the clamps, removing the diseased segment of bowel with its mesentery. The peritoneum and mesentery are sutured and the wound closed snugly about the two arms of bowel held in the clamp. Tension on the protruding bowel should be avoided. A tongue of peritoneum is sutured between the loops of the bowel under the clamp. Sutures are not placed in the bowel. The remainder of the abdominal wound is closed in the usual manner.

The clamp is left on the protruding bowel for forty-eight to sixty hours, at which time the proximal bowel is opened to relieve obstruction. The clamp on the distal segment is left until it drops off, usually within seven days. A crushing clamp or enterotome is then placed on the spur, which necroses through in six to eight days. By this means the fecal stream is re-established, and the fistula will tend to close spontaneously. If the protruding mucosa is cut or burned away down to the abdominal wall, many colostomies will close without the third step or operative closure. If the fistula does not heal, it should be closed in four to eight weeks, using local anesthesia.

TECHNIQUE OF THE MODIFIED PAUL-MIKULICZ RESECTION (FIGS. 494, 495)

This procedure is presented largely for its historical interest.

The bowel is mobilized and the mesentery divided as described above for the Rankin obstructive technique. The proximal and distal segments of the bowel are united along the taenia with two rows of continuous Lembert sutures of no. 00 chromic catgut a distance of 8 to 10 cm. The loop to be resected is lifted from the abdomen, and the abdominal wall is closed snugly about the double-barrelled segment. The bowel is not sutured to the abdominal wall. A small rubber tube may be passed between the distal stitches to aid in preventing retraction of the bowel into the abdomen. At the next step, instead of leaving the exteriorized loop attached to be removed later, it is cut away between clamps, and the obstructive clamps are left attached as described in the Rankin technique. A loop of bowel left attached without its blood supply will rapidly become necrotic, and the character of the pathologic process will be unidentifiable.

After seven to ten days a crushing clamp is applied to the spur and left in place until necrosis frees it. The protruding mucosa is then cut away flush with the abdominal wall. After a wait of six to eight weeks the fistula may be closed, using local anesthesia.

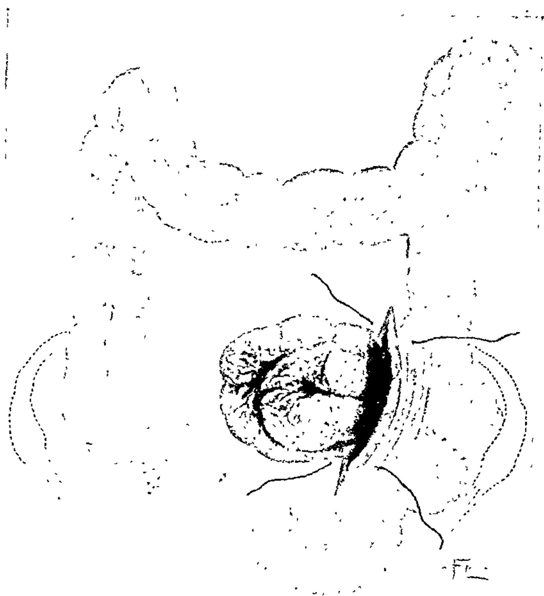


FIGURE 494 Mikulicz exteriorization procedure for carcinoma of the sigmoid, showing proximal and distal segments of the bowel sutured together. (Rankin, Bargen and Buie Colon, Rectum and Anus)

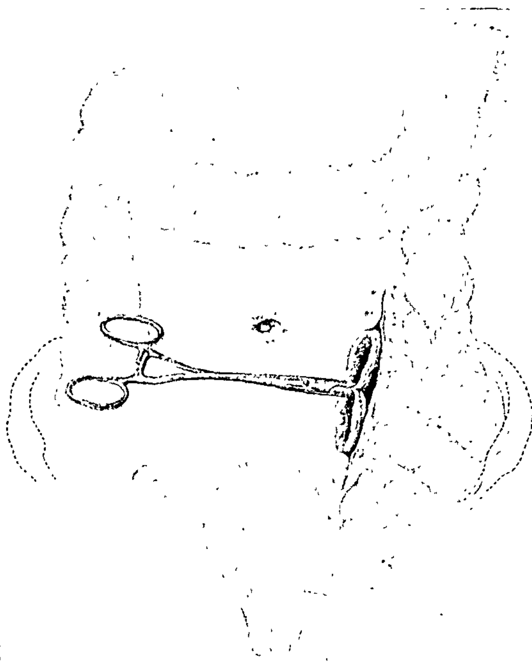


FIGURE 495. Mikulicz exteriorization procedure (*continued*) Exteriorized segment of bowel has been removed. A clamp has been applied to crush the septum between the proximal and distal segments of bowel. (Rankin, Bargen and Buie Colon, Rectum and Anus)

ABDOMINOPERINEAL EXCISION OF RECTUM

General Considerations

The chief indication for this operation is carcinoma of the rectum or rectosigmoid colon. It is by far the best operation for a large percentage of malignancies involving this region. Compared with other operations, it more nearly fulfills the requirement that the tumor with its adjacent lymphatics be removed to obtain the highest percentage of cures. Gilchrist and David have found that 68 per cent of all operatively removed specimens of carcinoma of the rectum have metastases to lymph nodes.

Although the various types of sphincter-saving operations continue to be practiced in certain areas, the general tendency has been toward extension of the classic

Miles operation to include ligation of the inferior mesenteric artery at its origin from the aorta and removal of the intervening mesentery and abdominopelvic lymph channels and nodes.

The two-stage operation is rarely indicated today. Some authors advise that the patient be placed and draped in the lithotomy position so that the abdominal and perineal portions of the procedure can be done simultaneously.

Dangers and Safeguards

The *preoperative study and preparation* of the patient are of primary importance. If intestinal obstruction exists, it is imperative that it be treated first. Resections of the obstructed colon have a forbidding mortality rate. Drainage and irrigation of the obstructed colon by cecostomy or colostomy, some distance proximal to the obstruction, will decompress the bowel and prepare it for resection.

Before operation the bowel should be cleansed mechanically with warm saline irrigations, and antimicrobial drugs should be given to reduce the bacterial count as for other colon surgery.

An indwelling catheter should be placed in the bladder before operation and left in place until the patient has become ambulatory and can completely empty the bladder. In many cases it is desirable to place catheters in both ureters before operation so that these structures may be identified and protected from injury with greater ease.

Secondary anemia should be treated by transfusions. It is preferable not to operate when the hemoglobin is below 70 per cent. An estimate of the heart and kidney functions is essential. During the four to seven days of preoperative preparation a high caloric nonresidue diet is advisable. Water balance should be maintained.

Surgeons differ in their choice of anesthetic agents. Spinal anesthesia alone or combined with gas anesthesia gives excellent relaxation. Local infiltration of the abdominal wall with 0.5 per cent Novocain combined with gas-ether inhalation anesthesia is satisfactory. A skilled anesthetist is usually more important than the selection of the anesthetic agent.

As a safeguard against shock, intravenous infusion of 5 per cent dextrose should be given during the operation. If there is evidence of shock during or at the completion of the operation, a transfusion should be promptly given and later repeated.

There are two major operative dangers. These are *contamination of the peritoneum* with bowel content and *damage to the blood supply* of the remaining colon. Section of the colon with a cautery between clamps or immediate closure of the severed colon ends by suture or protective rubber sheeting will reduce the danger of contamination. A careful identification of the blood supply to the bowel will avoid later gangrene and leakage into the peritoneum or wound.

Technique of Operation (Figs. 496, 497)

The steep Trendelenburg position is necessary for good pelvic exposure. A paramedian incision is made extending from the pubes upward above the level of the umbilicus The abdomen is systematically explored for metastases. This exploration should include the liver, pyloric area, pancreatic and bile duct areas, entire colon, retroperitoneal areas about the aorta and iliac vessels, mesentery of the sigmoid, and peritoneal surfaces of the pelvic peritoneum. Lastly, the growth should be gently

examined for extension through the bowel wall and fixation to surrounding structures.

The sigmoid is mobilized by severing the peritoneal folds to its left. The superior hemorrhoidal vessels are next identified above the level of the sacral promontory, doubly ligated with chromic catgut, and severed just below the sigmoid branch. This controls all important bleeding during the remainder of the operation. The blood supply to the sigmoid loop must be carefully preserved. The middle hemorrhoidal vessels deep in the pelvis on each side should be ligated after the sigmoid and upper rectum have been freed. They are usually small, and severe bleeding is not to be anticipated.

The peritoneum on each side of the sigmoid and rectum is divided deep into the pelvis, and these incisions are united in front of the rectum at the reflection on the bladder in the male and upper vagina in the female. The lower sigmoid and upper rectum, with mesenteric fat and lymphatic glands, are removed downward from the sacral promontory by blunt dissection with the hand. This dissection is carried along the hollow of the sacrum to the coccyx. The rectum is then dissected free anteriorly, avoiding injury to the bladder, seminal vesicles and prostate in the male. Traction on the rectum will expose its lateral attachments containing the middle hemorrhoidal vessels. At this point a ligature may be passed beneath these vessels and tied. Division of the lateral attachments deep in the pelvis facilitates the removal of the rectum from below. The pelvic peritoneum on each side is dissected up to make peritoneal flaps for the construction of the new pelvic floor. The ureter should be identified on each side to avoid accidental injury.

The sigmoid is sectioned after the pelvic dissection has been completed. It is divided with a cautery between Payr clamps or specially designed clamps such as the DeMartel. Each end of the severed bowel is firmly tied with a heavy silk ligature and covered with a rubber dam firmly held in place by a ligature. Jones states that this method of treating the severed bowel is quicker than the suture method and less apt to cause peritoneal contamination. The distal bowel is folded deep in the pelvis. Over this the new pelvic floor is reconstructed by suturing the peritoneum with two rows of chromic catgut. If the peritoneum is deficient, the uterus and broad ligaments in the female, or the peritoneum reflected from the bladder in the male, may be utilized. An omental patch may be used to reinforce the suture line.

The proximal end of the sigmoid is brought out through the upper end of the incision near the umbilicus. If the mesosigmoid is short, a stab wound should be made at the outer margin of the left rectus muscle on a line between the anterior superior spine and the umbilicus and the colostomy made at this point. When this is done, the space between the sigmoid and the lateral abdominal wall should be closed to prevent strangulated hernia. Any excess of gut protruding is not important, since it may be removed later. After healing, at least 2.5 cm. of bowel should protrude from the abdominal wall The bowel proper should not be sutured to the abdominal wall. Stitches so placed may later leak and produce peritonitis or an infected wound. The epiploic appendages may be sutured to the peritoneum or fascia. Danger of bowel retraction into the abdomen is not great, especially if a clamp is left on the protruding portion for a few days. The abdominal wound is closed snugly about the protruding bowel and covered with a collodion dressing or petrolatum gauze. The protruding stump of bowel is wrapped with petrolatum gauze.

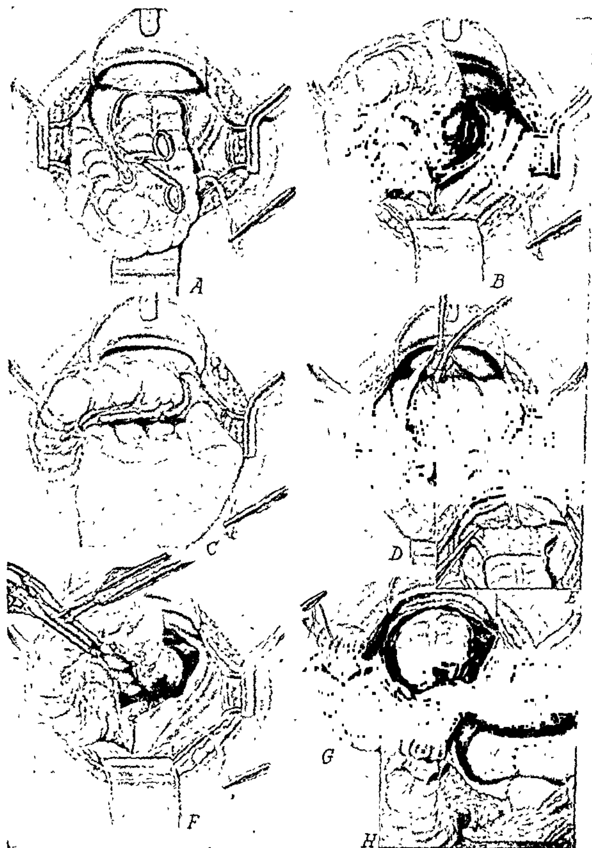


FIGURE 496. *One-stage abdominoperineal resection of the rectum* *A*, Exposure of cul-de-sac and beginning mobilization of rectum by division of lateral peritoneal attachments *B*, *Division of the medial peritoneal layer of the mesentery and exposure of the inferior mesenteric and superior hemorrhoidal vessels* *C*, Hand dissection of rectum from sacrum down to coccyx. *D*, Separation of the rectum from the bladder *E*, Division of triangular fascial bands containing middle hemorrhoidal vessels. *F*, Division of the sigmoid between clamps with the cautery *G*, Distal segment of bowel tucked deep into the pelvis. *H*, Pelvic floor reconstructed. (Redrawn from David: Lewis' Practice of Surgery, Vol. VII.)

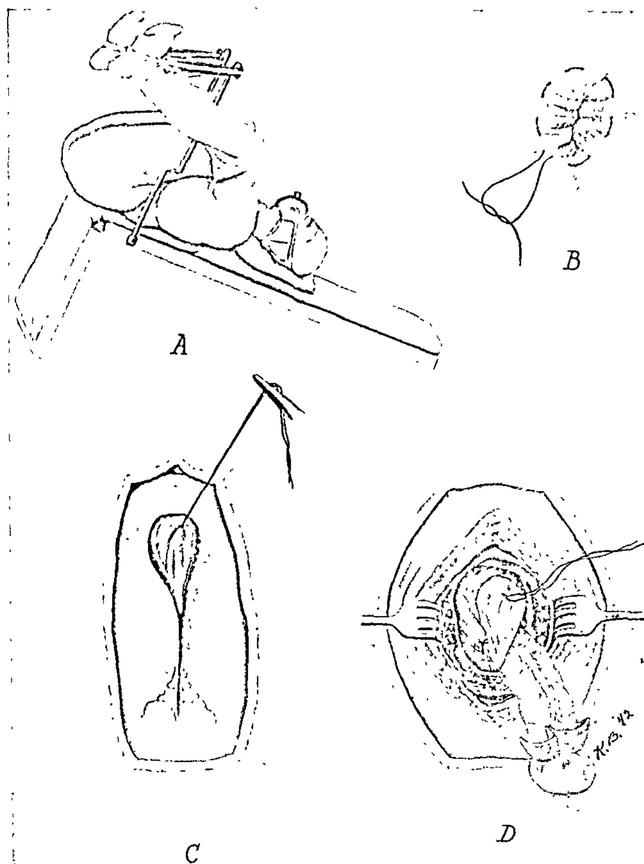


FIGURE 497. Perineal dissection of the combined abdominoperineal resection of the rectum *A*, Exaggerated lithotomy position. *B*, Purse-string of strong silk about anus *C*, Incision about anus extending backward to tip of sacrum. *D*, Lower sigmoid and rectum being delivered through perineal wound.

For the *perineal stage* of the operation, most surgeons recommend that the patient be turned on the abdomen or side with flexion at the hips. An exaggerated lithotomy position gives ample exposure and avoids turning the patient on the table (Fig. 497). A heavy purse-string suture is placed about the anus and firmly tied to prevent leakage during the operative manipulation. An incision is made around the anus and extended to the coccyx. The coccyx may be disarticulated, but this step is not always necessary for adequate exposure. The presacral fascia is incised. This permits entrance into the pelvic cavity. A branch of the mid-sacral artery may require ligation. Proceeding forward from the coccyx, the pararectal fat is freed from the pelvic wall. The levator ani muscles are exposed and, with the finger hooked above this muscle on each side, divided as far from the rectum as possible. The freed lower sigmoid and upper rectum are withdrawn from the pelvis, and dissection is made from above downward to separate the rectum from the prostate and urethra or vagina by sharp and blunt dissection. The line of cleavage must be followed carefully to avoid injury to structures anterior to the rectum. The perineal structures are divided by sharp dissection. A few small bleeding vessels may require ligation. The wound may be left open, in which case a square of rubber dam packed with gauze is introduced to fill the pelvic space and support the new pelvic floor, or the edges may be closed loosely around a Penrose drain. The pack may be removed in three to five days followed by daily saline irrigations.

A tranfusion of 500 ml. of blood should be given either on the operating table or immediately after the patient has been put to bed. An infusion of 5 per cent dextrose solution should be started immediately after the transfusion.

Technique of Extended Abdominoperineal Resection (State) (Figs. 498, 499)

Extension of the classical Miles operation as described by State and others is being practiced with increasing frequency for carcinoma of the rectum and rectosigmoid. In essence this consists in ligation of the inferior mesenteric artery at its origin from the aorta, thus necessitating removal of the entire left colon along with its mesentery and the establishment of a colostomy using the distal transverse colon or splenic flexure, as well as a thorough dissection of the preaortic and iliac lymphatic channels and nodes.

A long left rectus incision or oblique incision or, if preferred, a combination of the two is suitable, depending upon the preference of the operator and the habitus of the patient. After exploration of the abdomen the posterior peritoneum is opened near the ligament of Treitz and the inferior mesenteric artery and vein are ligated and divided. The posterior peritoneum is then incised from this region downward and to the right over the vena cava and the right iliac vessels down into the pelvis. The lateral peritoneal attachment of the sigmoid and left colon is then incised up to the splenic flexure, permitting mobilization of the entire left colon and sigmoid. The colon is then transected between clamps in the region of the distal transverse colon or splenic flexure, making certain that an adequate blood supply remains, and the mesentery is divided obliquely downward to the point of ligature of the inferior mesenteric artery.

The entire left colon along with its mesentery is then dissected downward into the pelvis. The lymphatic and areolar tissues overlying the aorta and vena cava are



FIGURE 498. Technique of extended abdominoperineal resection. The "hockey-stick" type of incision and optional sites of colostomy stoma are shown in the inset *a*. The posterior parietal peritoneum has been incised from the ligament of Treitz downward to the pelvic mesocolon, and the inferior mesenteric artery is ligated and divided at its origin *b*. Line of incision in the lateral leaf of the parietal peritoneum in the region of the sigmoid. *c*. Level of transection of the transverse colon and division of the mesocolon downward to meet the incision in the posterior parietal perineum. (D. State Surgery, Vol 30.)

likewise dissected from above downward to the bifurcation of the aorta and in the region between the iliac vessels. The rectum is then dissected from the hollow of the sacrum down to the coccyx as well as laterally and anteriorly as for the Miles operation. The sigmoid colon is then transected, using the DeMartel clamp, and the proximal portion of the colon removed so that the remaining segment can be folded into the hollow of the sacrum. The proximal portion of the transverse colon is then brought out to form a permanent colostomy stoma. The dissected area is then reperitonealized by approximating the cut edges of remaining peritoneum, although in many instances it will not be possible fully to reconstruct the pelvic floor, in which case this area is left open.

The abdomen is then closed and the patient placed in the dorsal lithotomy position for the perineal stage of the operation. This is carried out as described for the classical Miles operation. The perineal wound is closed loosely around cigarette drains.

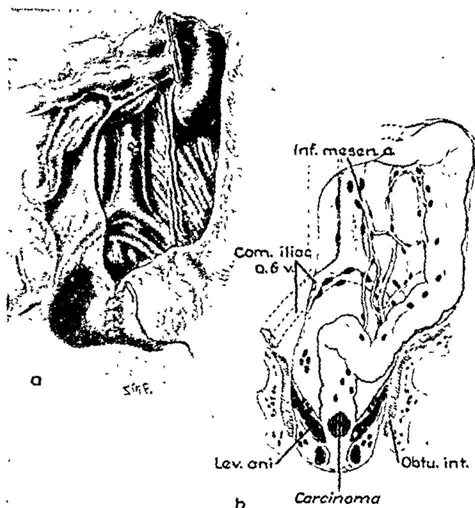


FIGURE 499 Extended abdominoperineal resection (*concluded*) *a*, The left colon and mesentery have been removed and the lymph-node-bearing area of the preaortic and pelvic areas dissected. The pelvic floor is being reconstructed. *b*, Diagram to show the extent of tissue removed. (D. State: Surgery, Vol. 30.)

RESECTION OF UPPER RECTUM AND RECTOSIGMOID FOR CARCINOMA WITH PRESERVATION OF LOWER RECTUM AND ANUS

General Considerations

Resection of the upper rectum and lower sigmoid with end-to-end anastomosis is indicated in well selected cases of carcinoma of the upper rectum, rectosigmoid junction and lower sigmoid. No one can question the desirability of re-establishing the continuity of the colon after resection to avoid the disagreeable features of a colostomy. *Local lesions, which show no evidence of extension through the bowel wall*, regional or distant metastases, are suitable for this operation. In certain cases, with distant metastases, a resection and anastomosis may be indicated as a palliative operation. The studies of Gilchrist and David and the later investigations of Coller, Kay and MacIntyre have shown that cancer of the rectum generally spreads upward except in cases having lymph node blockage with cancer cells, when downward or retrograde metastases may occur. These studies establish the validity of resection and primary anastomosis when the lesion, as far as can be determined, has not extended beyond

the rectal or colon wall, and when the technical difficulties are not too great because of the location of the tumor in the lower rectum. If there is any doubt about the extension of the tumor beyond the bowel wall, or if adjacent structures are involved, the classical abdominoperineal resection of Miles is the operation of choice. In certain poor-risk patients, resection with permanent colostomy and closure of the rectum may be indicated. If there is no evidence of metastases or local recurrence of the cancer, anastomosis may be considered later.

If an obstruction exists, resection and anastomosis should not be attempted until the colon has been adequately decompressed by a preliminary colostomy. If there is no obstruction, a preliminary or complemental colostomy is not necessary.

Technique of Resection with Permanent Colostomy

The sigmoid and upper rectum are mobilized down to or below the rectosigmoid junction, depending upon the location of the lesion. The superior hemorrhoidal vessels

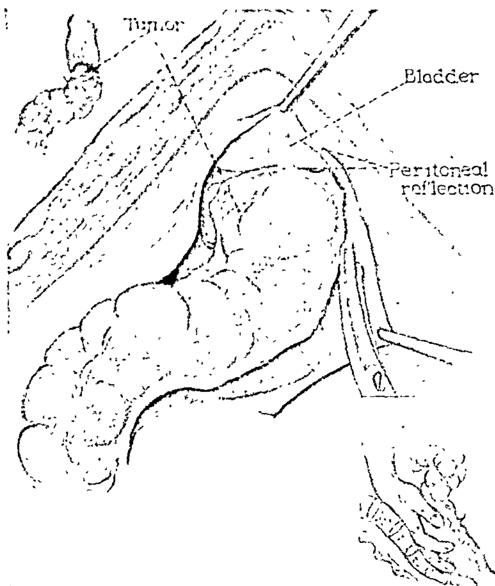


FIGURE 500. Dixon technique of resection of lower sigmoid and upper rectum, with end-to-end anastomosis. Upper inset shows location of tumor to be removed. The rectum and sigmoid are freed as in the abdominoperineal resection. (Dixon. Surgery, Vol. 15, C. V. Mosby Company.)

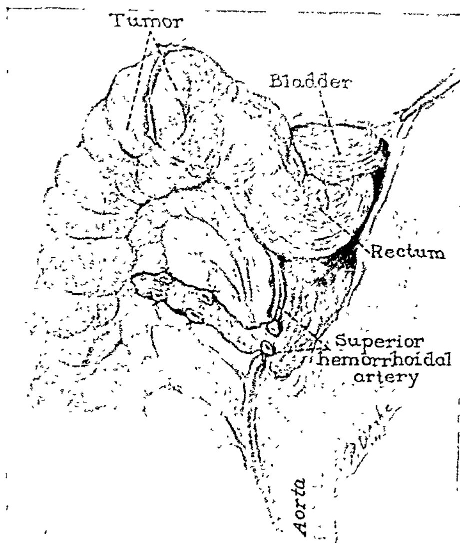


FIGURE 501. Dixon technique of resection of lower sigmoid and upper rectum with end-to-end anastomosis (*continued*) The rectum and sigmoid have been mobilized. Ligation of the superior hemorrhoidal artery and smaller mesenteric vessels shown in detail. Note that sigmoid arteries are visualized in the mesentery. (Dixon: Surgery, Vol 15, C. V. Mosby Company.)

are severed and ligated as in the combined abdominoperineal operation. Crushing clamps are applied at the points chosen for section, and the intervening segment of bowel is removed with its mesentery. The rectum is closed with a double row of sutures, and the proximal sigmoid is placed in the upper end of the abdominal incision or withdrawn through a stab wound to make the colostomy.

A pelvic floor is constructed over the rectal stump. A drain should be passed beneath the pelvic floor either through the abdomen or through a stab wound made in front of the coccyx.

Technique of Resection and Anastomosis

Dixon Technique (Figs. 500 to 503). A low left rectus incision is made near the midline. The abdomen is carefully explored for metastases and local extension of the tumor. If the tumor is resectable, the lower sigmoid and rectum are freed as in the combined abdominoperineal resection. Traction is made on the lower sigmoid and rectum with a tape placed beneath the bowel. The bladder in the male, or vagina in the female, is carefully separated from the rectum. The superior hemorrhoidal vessels

are divided and ligated below the sigmoid branches. The blood supply to the rectum comes from the middle and inferior hemorrhoidal vessels.

After the upper rectum and lower sigmoid have been freed, rubber-shod clamps are applied at the sites chosen for section of the bowel, and the intervening segment is removed. An end-to-end anastomosis is made with two rows of sutures.

If the lower sigmoid mesentery is too short to permit anastomosis, the lowest sigmoid artery and end of sigmoid colon may be resected so that the proximal and distal ends of the bowel may be easily approximated. In rare cases it may be necessary to mobilize the descending colon as far up as the splenic flexure. The blood supply to the sigmoid must be visualized and safeguarded.

After completion of the anastomosis a drain is passed down to the sacrum and brought out at the lower end of the abdominal incision. The pelvic floor is reconstructed about the sigmoid so that the anastomosis lies retroperitoneally.

Wangensteen Technique (Figs. 504, 505, 506). Lesions in the rectum, of which the visible or palpable edge is more than 10 cm. from the pectinate line, are classified as

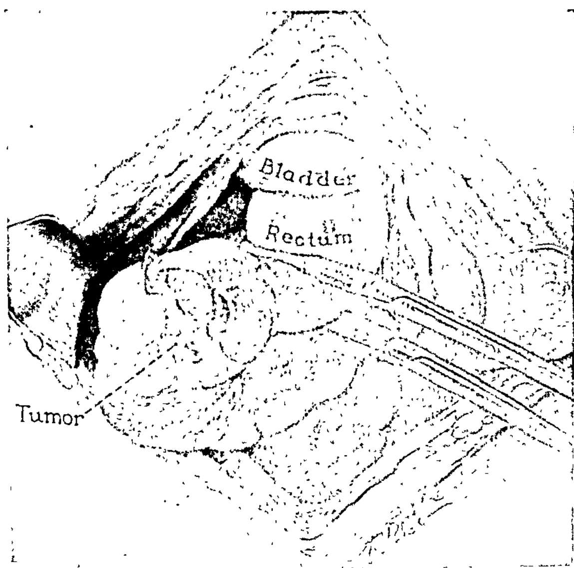


FIGURE 502. Dixon technique of resection of lower sigmoid and upper rectum, with end-to-end anastomosis (*continued*). Rubber-shod clamps are placed on the rectum and sigmoid at the points selected for division of the bowel. (Dixon: Surgery, Vol 15, C. V. Mosby Company.)

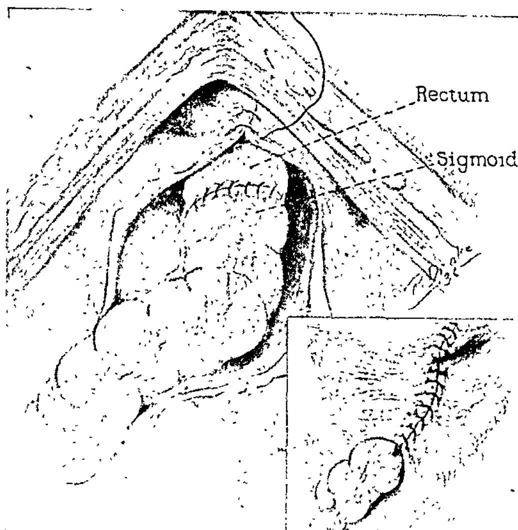


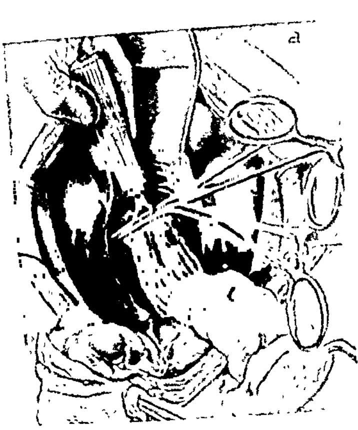
FIGURE 503. Dixon technique of resection of lower sigmoid and upper rectum with end-to-end anastomosis *(concluded)* *Anastomosis has been completed between the first portion of the sigmoid and* upper part of the rectum. The pelvic peritoneum is closed about the sigmoid above the anastomosis. (Dixon, Surgery, Vol 15, C. V. Mosby Company)

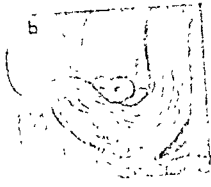
rectosigmoid, and those within 10 cm. (or less) of the pectinate line are grouped as ampullary lesions.

The patient is placed in the steep Trendelenburg position. A left paramedian incision is made extending from the pubes to or above the level of the umbilicus. The *details of mobilization of the rectum and sigmoid are identical with those of the ab-*dominoperineal resection. The rectum is mobilized sufficiently to ensure excision of 3 cm. of rectal mucosa distal to the lesion.

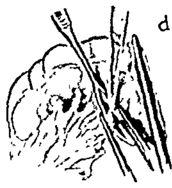
Wangensteen clamps are applied on the rectum and sigmoid at points chosen for resection of the bowel, and the intervening segment with its mesentery is removed. *The end of the sigmoid is carefully prepared for anastomosis by removing all fatty* epiploic appendages. The clamps are placed together with a locking device, and the anastomosis is made with interrupted Lembert sutures of fine silk.

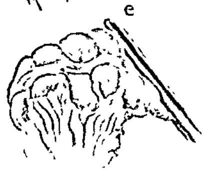
The pelvic floor is reconstructed about the sigmoid above the site of anastomosis. A drain is passed from the presacral space through a stab wound made in front of the coccyx. The drain may be placed either before or after closure of the pelvic floor. A rectal tube is passed through the anastomosis and left in place for six or seven days. The tube should be partially withdrawn after the third day to prevent pressure necrosis. An indwelling Wangensteen suction tube is used for three to five days.











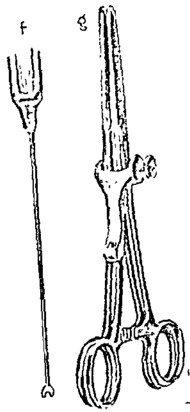


FIG ... f rectal ampulla *a*, The rectum and sigmoic ... f ... uon of cla ... rectal stur ... g., Gynec. & Obst., Vol. 81. By permission of Surgery, ...

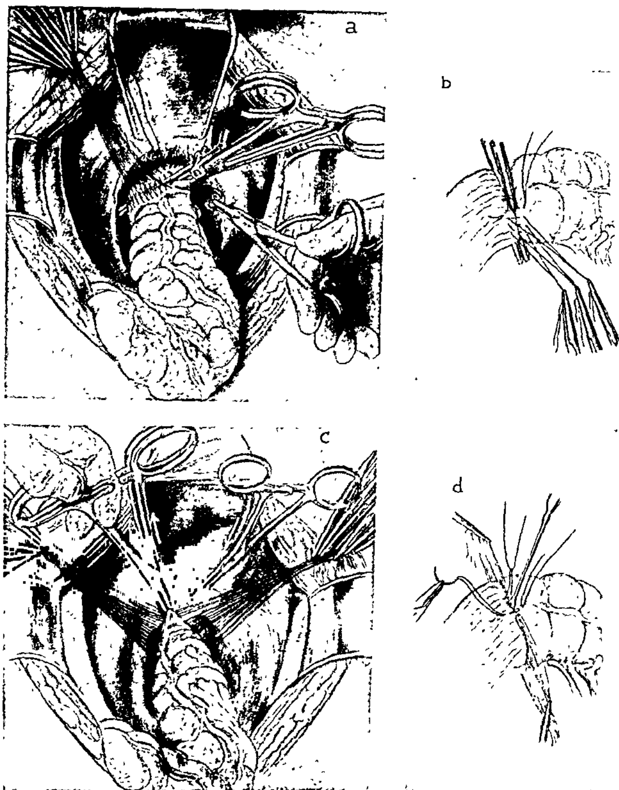


FIGURE 505 Wangensteen technique of primary resection of rectal ampulla (*continued*) *a*, Lembert sutures of silk placed over locked clamps. *b*, Details of suture. Each suture is clipped separately with a fine hemostat *c*, Both anterior and posterior rows of Lembert sutures have been placed. The clamps are removed separately as the sutures are drawn taut *d*, Sutures are being tied. Additional sutures are used if approximation or inversion of bowel margins is unsatisfactory. (Wangensteen· Surg., Gynec. & Obst., Vol 81 By permission of Surgery, Gynecology and Obstetrics)

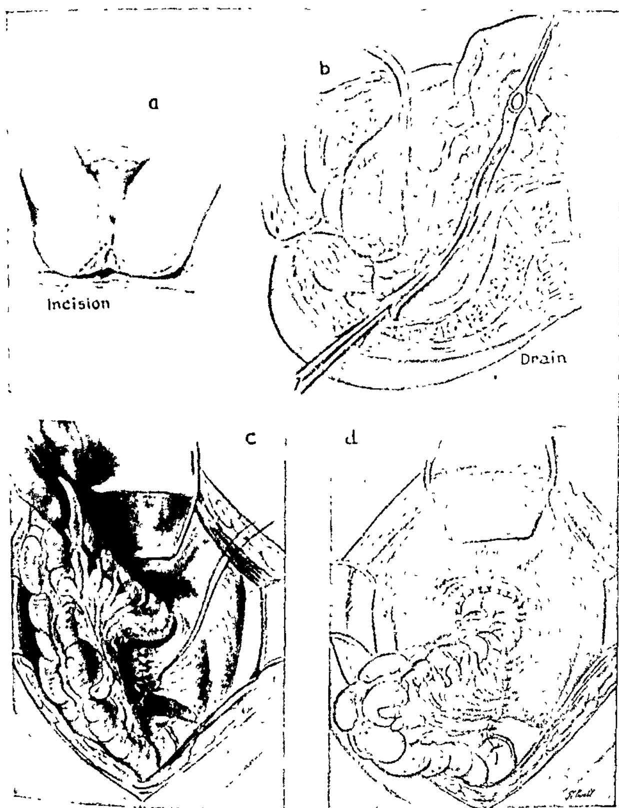


FIGURE 506. Wangensteen technique of primary resection of the rectal ampulla (*concluded*). *a*, Short incision in perineum just anterior to coccyx. *b*, Penrose drain is drawn through from below. *c*, Peritoneal flaps are sutured together beneath the pelvic colon to deepen the cul-de-sac. *d*, Lateral peritoneal flaps sutured to bowel and mesentery, making a double closure of the peritoneal floor. The anastomosis is below the peritoneal floor. (Wangensteen: Surg., Gynec. & Obst., Vol. 81. By permission of Surgery, Gynecology and Obstetrics.)

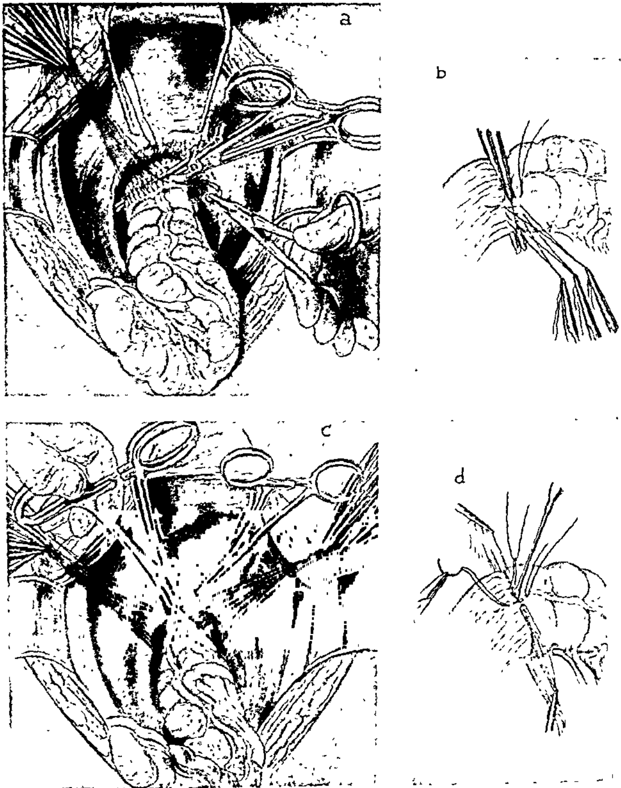


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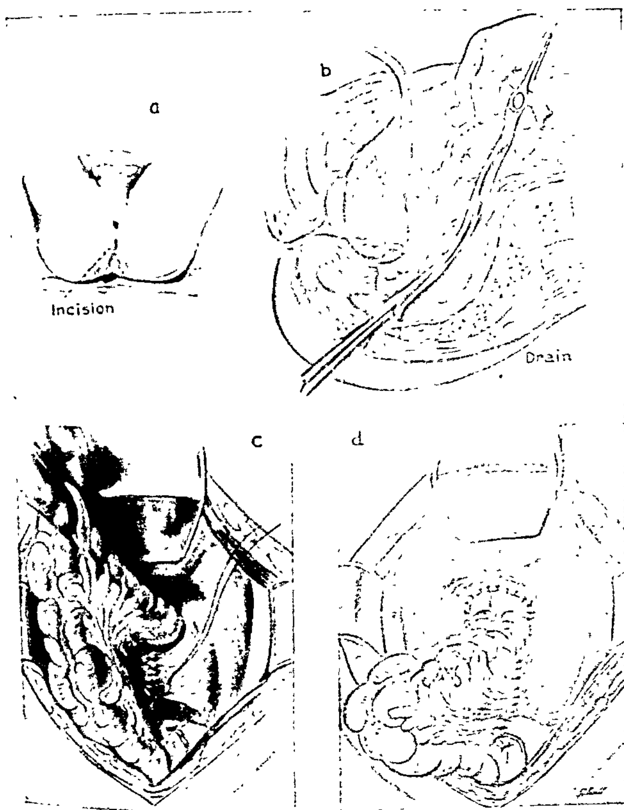


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BENIGN TUMORS OF THE RECTUM

... of Removal

... and papillomas can usually be removed through the anus. As ... evidence of malignant change, a microscopic study of all ... made. If they are found to be malignant, they should be ... of the rectum.

... dilated and held open by a speculum or retractors. ... near the anus, tumors are easily removed with knife ... they may be grasped with forceps and removed by ... Bleeding is controlled by careful suture. Open ...

... tumor, high in the rectum, may be removed ... tonsil snare and severing it by fulguration.

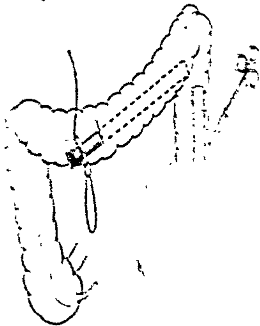
POLYPECTOMY

... and rectum are frequently precancerous lesions ... destroyed as soon as found.

... or can be withdrawn from the anus are re... Pedunculated polyps in the rectum and ... fulguration through a proctoscope or sigmoido... ... may also be removed by fulguration. ... adenomas existing above the peritoneal reflec... ... abdominal incision.

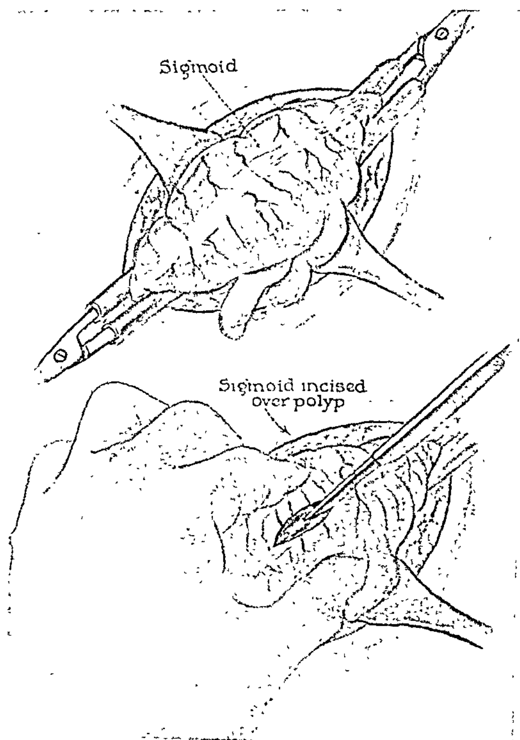


FIGURE 505 ... sutures of silk pla... a fine hemostat *c*, ... are removed sepa... are used if approxi... & Obst., Vol 81. .



Technique of Polypectomy (Figs. 507, 508, 509)

After the abdomen has been opened the lesion should be examined carefully for evidence of malignancy. If the tumor is large and there is evidence that it may be malignant, a bowel resection is the operation of choice. If there is no induration or dimpling of the bowel wall, the tumor is removed through an opening in the colon. A rubber-shod clamp is applied to the bowel. The tumor is grasped between the



olypectomy of colon and rectum. The sigmoid containing the polyp is ' the incision is made along the longitudinal muscle band. (David. ,.)

BENIGN TUMORS OF THE RECTUM

Technique of Removal

Polyps, adenomas and papillomas can usually be removed through the anus. As such tumors may show some evidence of malignant change, a microscopic study of all growths should always be made. If they are found to be malignant, they should be treated as carcinoma of the rectum.

The sphincter muscles are dilated and held open by a speculum or retractors. When pedunculated and located near the anus, tumors are easily removed with knife or cautery. If high in the rectum, they may be grasped with forceps and removed by an elliptical incision about the base. Bleeding is controlled by careful suture. Open vessels may retract beneath the mucosa and produce a hematoma. Fulguration may be the treatment of choice if the tumors are sessile, multiple, or in a location which makes excision difficult. A pedunculated tumor, high in the rectum, may be removed by encircling its pedicle with an ordinary tonsil snare and severing it by fulguration.

POLYPECTOMY

General Considerations

Polyps and adenomas of the colon and rectum are frequently precancerous lesions and should be removed or completely destroyed as soon as found.

Polyps or adenomas which prolapse or can be withdrawn from the anus are removed by ligation of the pedicle and excision. Pedunculated polyps in the rectum and lower sigmoid may be removed by fulguration through a proctoscope or sigmoidoscope. Flat adenomas or areas of hyperplasia may also be removed by fulguration.

Large pedunculated polyps or flat adenomas existing above the peritoneal reflection are removed through an abdominal incision.

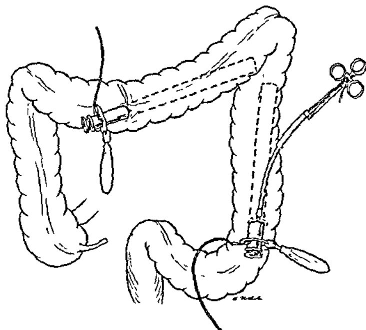


FIGURE 507. The sites of colotomy through which the entire colon can be visualized in most instances (G. A. Higgins. Am. Surgeon, Vol. 22.)

Technique of Polypectomy (Figs. 507, 508, 509)

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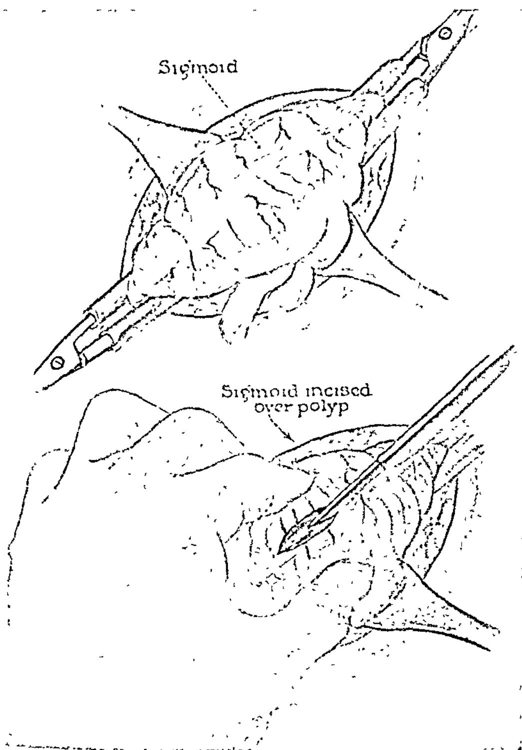


FIGURE 508. Technique of polypectomy of colon and rectum. The sigmoid containing the polyp is held in a rubber-shod clamp, and the incision is made along the longitudinal muscle band. (David: Surgery, Vol. 14, C. V. Mosby Company)

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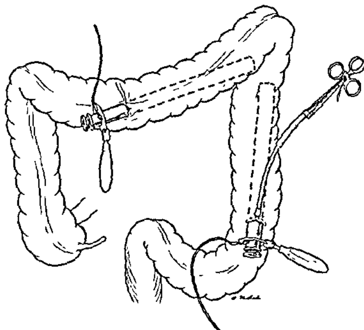


FIGURE 507. The sites of colotomy through which the entire colon can be visualized in most instances (G. A. Higgins. Am. Surgeon, Vol. 22.)

DIVERTICULITIS OF THE COLON

Diverticulitis without complication should be treated conservatively with rest, antispasmodic drugs, diet, the sulfonamides and penicillin, and sedation. If a diverticulum perforates into the peritoneal cavity, drainage is indicated. A proximal diverting colostomy should be done. A fistula may follow drainage. If an abscess forms, it should be drained, if possible, without peritoneal soiling. When the inflammatory process has subsided (usually four to six months), the involved segment should be resected.

It may be difficult or impossible to distinguish diverticulitis from carcinoma with perforation. For this reason undue delay may jeopardize the chances for cure, and operation must be done before subsidence of the inflammatory process.

PROLAPSE OF RECTUM

General Considerations

The types of rectal prolapse usually seen may be classified as mucosal, complete, and sigmoidorectal intussusception. Operation may be required for any of these types. Mucosal prolapse in adults, when associated with hemorrhoids, may be treated by hemorrhoidectomy with removal of strips of redundant mucosa by clamp and cautery or dissection. Minor degrees of mucosal prolapse may also be treated by linear cauterization of the protruding mucosa upward from the mucocutaneous line (Fig. 510).

Complete prolapse of the rectum frequently presents a difficult therapeutic problem. The many operative procedures which have been described for this condition are evidence that no single method has proved successful in all cases. Both external and intra-abdominal operations have been used. The external operation has been the favorite with most surgeons. Complete prolapse is considered a perineal hernia by most investigators of the subject, and intra-abdominal repair procedures have been recommended. The Moschcowitz operation is based on the belief that complete rectal prolapse is a sliding hernia. In this operation the pelvic cul-de-sac is obliterated by successive tiers of sutures.

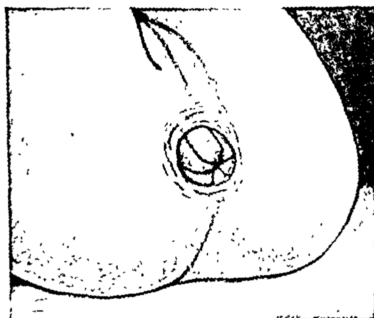


FIGURE 510. Cauterization of the rectal mucosa for prolapse. (Bickham: Operative Surgery.)

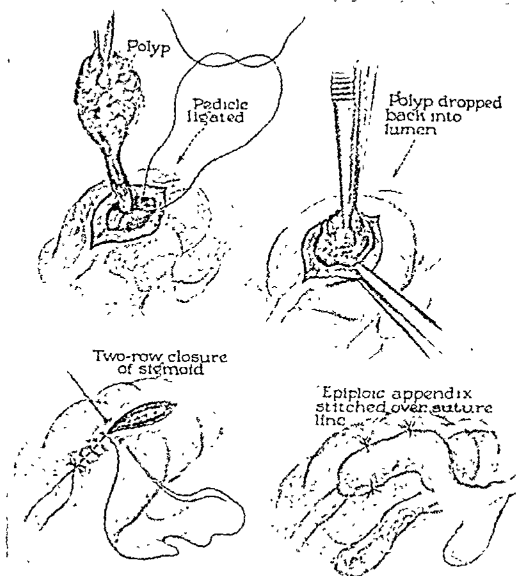


FIGURE 509. Technique of polypectomy of colon and rectum (*continued*) The pedicle of the polyp is ligated, and should be removed for microscopic examination. The bowel is closed with three rows of interrupted silk sutures. An epiploic appendix is used to reinforce the suture line. (David: Surgery, Vol. 14, C. V. Mosby Company.)

thumb and finger, and an incision is made through the longitudinal muscle band opposite the mesenteric attachment. The pedicle of the polyp is ligated close to the bowel wall. The polyp is removed for microscopic examination. The wound in the bowel is closed with three rows of fine silk. The outer row of sutures is used to cover the suture line with an appendix epiploica. It is wise to change gloves and instruments before closing the abdominal incision.

Identification of polyps through the intact colon may be difficult, and indeed many polyps may be missed by roentgenologic examination. For this reason it is desirable to examine the entire colon with a sterile sigmoidoscope at the time of exploratory operation for polyps. With good bowel preparation and careful precautions to avoid soilage, the hazards of contamination are minimal.

In many instances the entire colon can be examined through two colotomies, one at the junction of the sigmoid and descending colon and a second in the transverse colon slightly to the left of the midportion.

DIVERTICULITIS OF THE COLON

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PROLAPSE OF RECTUM

General Considerations

The types of rectal prolapse usually seen may be classified as mucosal, complete, and sigmoidorectal intussusception. Operation may be required for any of these types. Mucosal prolapse in adults, when associated with hemorrhoids, may be treated by hemorrhoidectomy with removal of strips of redundant mucosa by clamp and cautery or dissection. Minor degrees of mucosal prolapse may also be treated by linear cauterization of the protruding mucosa upward from the mucocutaneous line (Fig. 510).

Complete prolapse of the rectum frequently presents a difficult therapeutic problem. The many operative procedures which have been described for this condition are evidence that no single method has proved successful in all cases. Both external and intra-abdominal operations have been used. The external operation has been the favorite with most surgeons. Complete prolapse is considered a perineal hernia by most investigators of the subject, and intra-abdominal repair procedures have been recommended. The Moschcowitz operation is based on the belief that complete rectal prolapse is a sliding hernia. In this operation the pelvic cul-de-sac is obliterated by successive tiers of sutures.

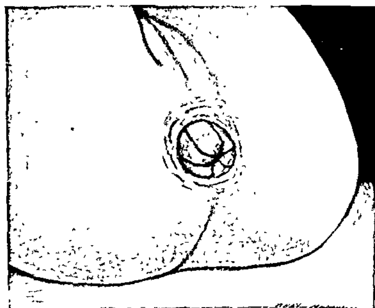


FIGURE 510. Cauterization of the rectal mucosa for prolapse. (Bickham: Operative Surgery.)

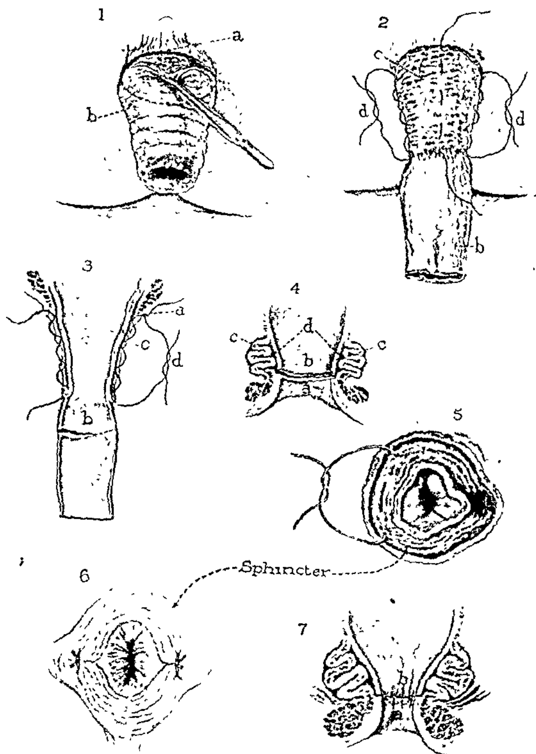


FIGURE 511. Modified Rehn-Délorme operation for prolapse of the rectum. *1*, Circular incision through mucosa at mucocutaneous line. *2*, Mucosa separated and sutures placed in muscularis. *3*, Longitudinal section of *2* *4*, Sutures tied, puckering the muscularis *5*, Cross section of external sphincter, showing catgut sutures placed to reduce the circumference of sphincter. *6*, Sutures tied in external sphincter, reducing the anal opening. *7*, Longitudinal section through the rectum, showing operation completed (David. Lewis' Practice of Surgery, Vol. VII, W F. Prior Co, Inc)

Technique of the Rehn-Délorme Operation as Modified by David (Fig. 511)

Local anesthesia is recommended. The usual circular anesthesia of the bowel is produced. The injection is carried upward into the levator ani attachment to the rectum. In addition, the procaine-epinephrine solution is injected beneath the mucosa of the prolapsed bowel to raise the mucosa and aid dissection.

An incision is made about the bowel at the mucocutaneous line, completely separating the mucosa and skin. By blunt dissection the mucosa is removed carefully from the prolapsed segment of bowel to avoid injury to the sphincter muscles. The mucosa is friable, and bleeding may make dissection tedious. Careful hemostasis is important. The mucosa is removed to the tip of the prolapsed segment.

The denuded muscularis is pleated longitudinally by four catgut sutures inserted from the mucocutaneous line to the apex of the protruding bowel. This shortened segment of bowel is pushed back into the pelvis. Mattress sutures of chromic catgut are inserted into one or more quadrants of the external sphincter and tied to lessen its circumference. The severed rectal mucosa is then sutured to the skin to form a new mucocutaneous line.

Technique of Suspension Operation for Prolapse of the Rectum (Figs. 512 to 515)

Two strips of fascia 1 to 2 cm. wide and 10 to 12 cm. long are excised from the fascia lata. This may be simplified by using a stripper specially designed for removal of fascia (Fig. 89, p. 109).

The patient is placed in the Trendelenburg position, and a paramedian incision is made from the pubes to a point about 2 cm. above the umbilicus. After packing the intestines away from the pelvis, the lower sigmoid is lifted into the wound, and a tape is passed beneath it for traction.

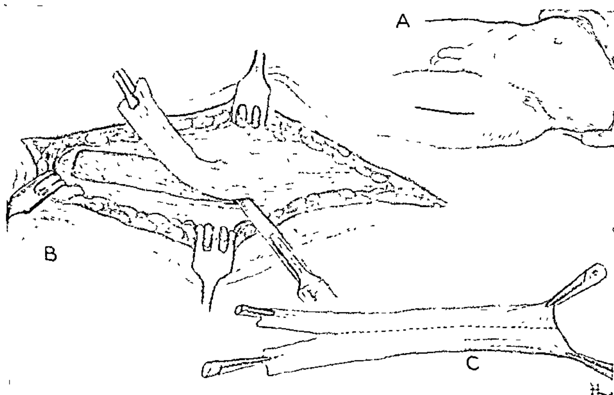


FIGURE 512 Suspension operation for prolapse of rectum. *A*, *B*, *C*, Technique of removal of fascial strips from fascia [illegible]

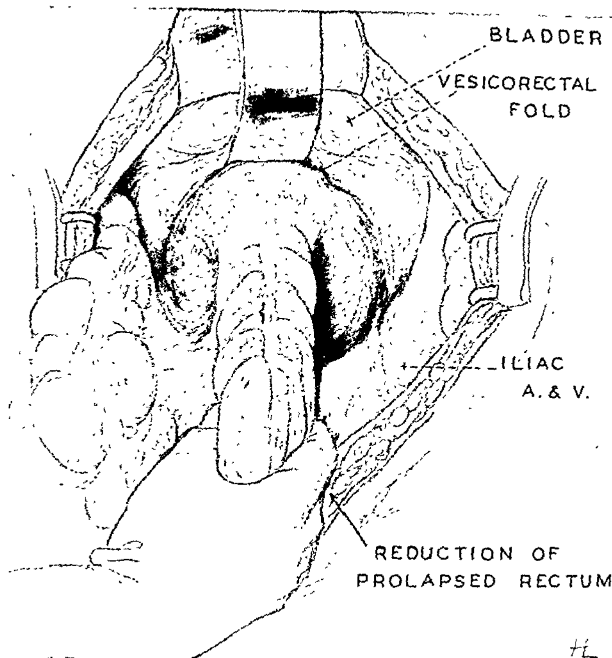


FIGURE 513 Suspension operation for prolapse of rectum (*continued*). Reduction of prolapsed rectum preliminary to suspension. Exposure and pelvic anatomy shown.

The fascia just above the promontory of the sacrum is exposed through an inverted T-shaped incision in the peritoneum. A strip of fascia is sutured to each side of the rectum with a double row of interrupted sutures of fine silk. The lower ends of the strips of fascia are attached to the rectum at its lowest point about the peritoneal reflexion The strip of fascia on the left is passed through a small puncture wound made in the mesentery of the sigmoid. While the rectum and lower sigmoid are held suspended the upper ends of the fascial strips are sutured to the dense fascia over the promontory of the sacrum with two rows of interrupted silk sutures. The cul-de-sac is obliterated by placing two or more rows of interrupted silk sutures transversely across the pelvis The peritoneum anterior to the rectum is sutured to the rectal wall as the transverse rows of sutures are placed. The pelvic operation is completed by suturing a fold of peritoneum to the rectal wall on each side to cover the fascial strips.

The abdominal and thigh wounds are closed with silk.

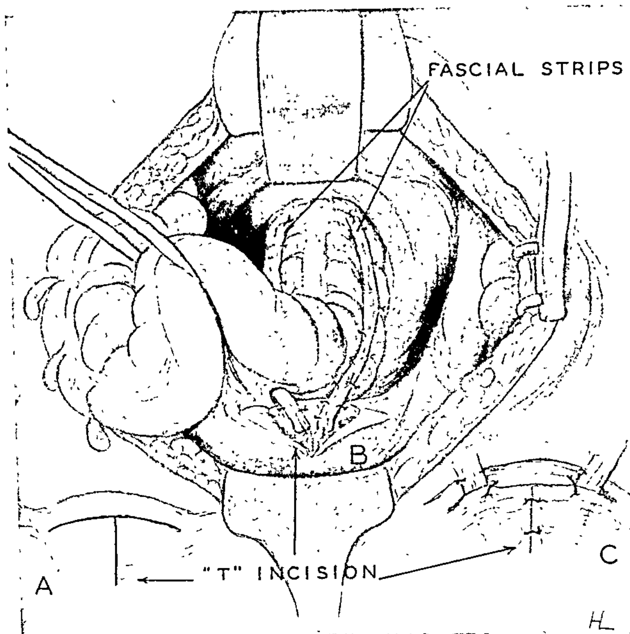


FIGURE 514 Suspension operation for prolapse of the rectum (*continued*) Strips of fascia lata have been sutured to the sides of the rectum and to the dense fascia over the sacral promontory. On the left the fascial strip is passed through the mesentery of the sigmoid. *A*, A T-shaped incision in the peritoneum is used to expose the sacral promontory fascia. *C*, Closure of T-shaped incision over ends of fascial strips.

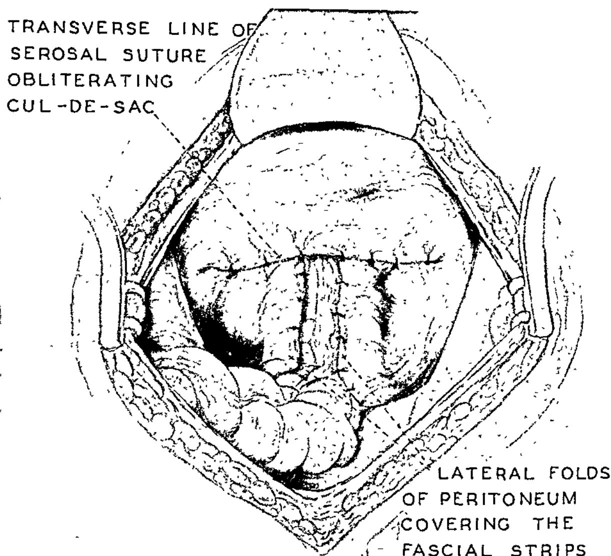


FIGURE 515. Suspension operation for prolapse of the rectum (*concluded*) Lateral folds of peritoneum are used to cover the fascial strips sutured to the rectal wall. Transverse closure of cul-de-sac with 3 or 4 rows of sutures

BENIGN STRICTURE OF THE RECTUM

Benign strictures are most commonly caused by lymphogranuloma venereum. They occur most frequently in Negro women. They may be short strictures near the anus, or the strictured area may extend from the anus into the sigmoid. The perirectal tissues are involved, and fistulas develop frequently in the perineal and perianal regions.

Short strictures may be treated with some degree of success by repeated dilatations. This type of treatment is not without danger because of the possibility of perforation of the rectum or sigmoid causing peritonitis. One of the author's patients died of multiple liver abscesses following digital dilatation. Cutting of strictures is of doubtful value. Extensive strictures are best treated by permanent colostomy. If a patient's general and local condition does not improve after colostomy, a combined abdominoperineal resection of the rectum and involved sigmoid is indicated.

RECTOVAGINAL FISTULA

General Considerations

A fistulous opening between the rectum and vagina may develop at any point along the vaginal wall from the cervix to the perineum. With extensive destruction of tissue, producing a large opening and excessive scarring, the repair of this type of

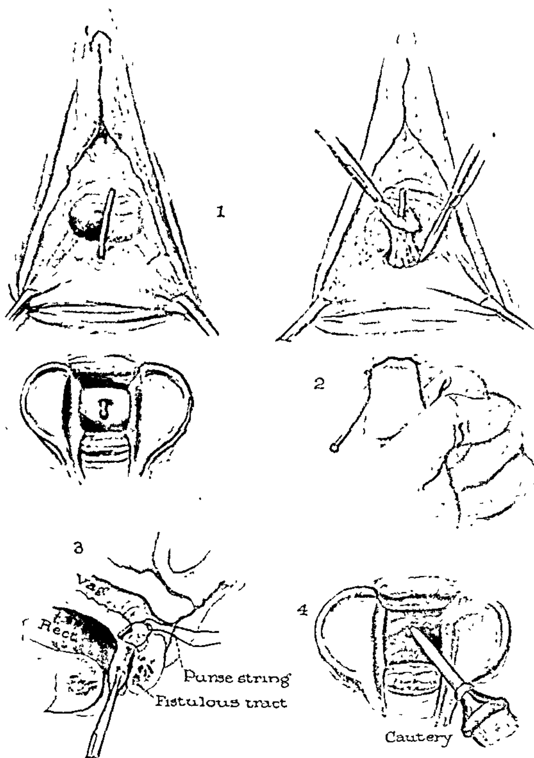


FIGURE 516. Repair of rectovaginal fistula 1, Probe passed through rectovaginal fistula, showir openings in rectum and vagina 2, Excision of fistulous tract from vaginal side by sharp dissectic down to the submucosa of the bowel. 3. Inversion of the fistulous tract into the rectum and purs string closure of muscularis of the bowel and perirectal tissue 4, Removal of fistulous tract with cauter (David. Lewis' Practice of Surgery, Vol VII, W. F Prior Co, Inc)

fistula may be technically difficult. If near or involving the sphincter muscles, these structures should be carefully repaired, if severed for the repair of the fistula.

Technique of Operation (David) (Fig. 516)

The fistulous tract is located by passing a probe from the vagina into the rectum and out through the dilated anus. The vaginal opening is mobilized by making a circular incision through the vaginal mucosa and down to but not through the rectal mucosa.

The tube of tissue containing the fistulous tract is turned inside out by drawing the vaginal end through the opening into the rectum. A purse-string suture is used to close the deep part of the vaginal wound. The fistulous tract protruding into the rectum is ligated and cut away or severed with the cautery.

CONGENITAL MEGACOLON

General Considerations

Congenital megacolon, or Hirschsprung's disease, is characterized by chronic constipation dating from birth with massive dilatation of the colon and episodes of intestinal obstruction. In 1949 Swenson, Neuhauser and Pickett showed the cause of this syndrome to be a congenital malformation of the sacral parasympathetic nervous system characterized by an absence of ganglion cells from Auerbach's plexus. This congenital defect may involve variable portions of the colon, but includes the rectum down to the region of the internal sphincter. A similar defect may be present in the bladder and ureters to a greater or less degree. The involved segment of bowel has no peristaltic activity, thus producing a relative obstruction with resultant dilatation of the colon proximal to the diseased area.

Resection of the aganglionic segment of bowel followed by a pull-through type of anastomosis of the normal proximal bowel with the terminal 1.5 cm. of rectum as devised by Swenson has become the standard operative treatment for this disease.

Diagnosis can usually be established by clinical findings and roentgenologic examination. Occasionally a biopsy of the full thickness of the rectal wall may be indicated to establish the diagnosis.

Before operation colonic irrigations of saline solution are used to evacuate the colon as well as possible. Provisions are made for administration of whole blood during the operation, and an indwelling catheter is placed in the urinary bladder.

In the newborn infant or in older children with severe forms of the disease, Swenson recommends that a preliminary colostomy be made in the dilated segment of colon just proximal to the aganglionic segment and that the pull-through procedure be done along with resection of the colostomy site as a secondary operation.

Technique of Operation (Swenson) (Figs. 517, 518, 519)

General anesthesia is used. The patient is placed in a modified lithotomy position so that both the abdomen and perineum can be exposed simultaneously. The abdomen is opened through a left rectus muscle-retracting incision and the abdomen explored. The diseased portion of bowel will appear of normal size, while the uninvolved portion

will be dilated and hypertrophied. The amount of bowel to be mobilized will depend upon the extent of involvement, and the vessels should be divided near their origin to ensure adequate blood supply to the proximal segment of the anastomosis through the arcades and marginal vessels. When sufficient bowel has been mobilized proximally to reach through the anus, the aganglionic segment is then excised. Dissection must be carried out close to the bowel wall to prevent damage to the innervation of the bladder and ejaculatory mechanism. Sharp dissection is used and is carried out to within 2 to 3 cm. of the mucocutaneous junction, ending just above the insertion of the levator muscles. The dilated portion of bowel is then divided 5 to 10 cm. proximal to the narrowed segment. Swenson recommends the de Petz sewing clamp for this purpose, although conventional intestinal clamps are suitable, in which case the proximal bowel is temporarily closed with sutures.

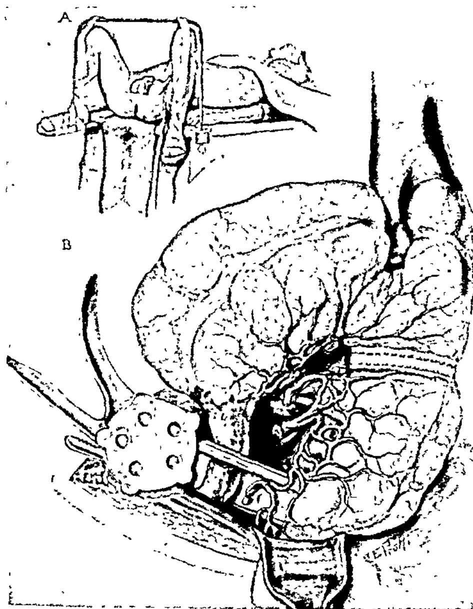


FIGURE 517 Resection of the colon for Hirschsprung's disease. *A*, Position of patient on the table to permit simultaneous abdominal and perineal exposure. *B*, The distal colon has been mobilized, taking care to ligate the vascular supply near its source to ensure adequate circulation to the pull-through segment by way of the vascular arcades The segment to be removed is divided between rows of staples applied with the de Petz clamp. (O. Swenson and H. J. Fisher: S. Clin. North America, Vol. 36)

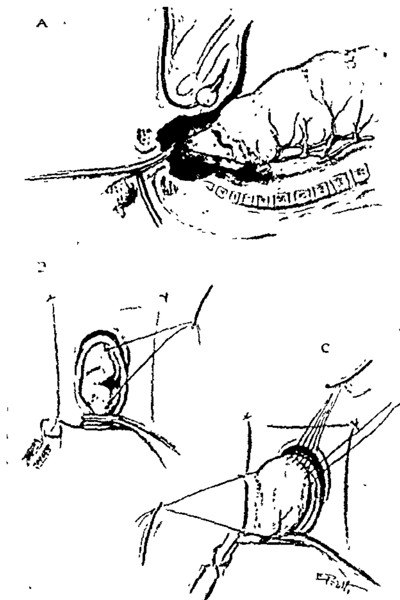


FIGURE 518 Resection of the colon for Hirschsprung's disease (*continued*) *A*, An incision has been made through the anterior wall of the inverted rectum, and the mobilized descending colon is being pulled out through the anus by means of an inserted clamp *B*, Perineal view showing the descending colon pulled through the inverted rectum ready for anastomosis. *C*, The first or outer layer of the anastomosis is started, using interrupted fine silk sutures (O. Swenson and H J Fisher: S. Clin North America, Vol. 36.)

The colon is then divided in the aganglionic area in a similar fashion. The removed segment is then examined by the pathologist to determine the presence of ganglion cells in the area of proximal excision; if none are found, the level of excision must be made more proximally. The removal of this segment of bowel also makes it possible to telescope the rectum through the anus for the perineal portion of the operation. The anal canal and 1.5 cm. of rectal mucosa must remain to ensure adequate sphincter reflexes.

When the inverted rectal stump has been telescoped out through the anus, this is prepared with antiseptics, and the perineum is draped. A second operating team is now used to perform the perineal portion of the operation. An incision is made through the anterior third of the inverted rectal wall 2 cm. from the mucocutaneous junction, and an instrument is passed through this incision into the pelvis. The closed end of the

mobilized portion of bowel is then grasped with the clamp and pulled out through the incision in the inverted rectal wall. The outer layer of anastomosis is then made by placing interrupted 5-0 silk sutures between the seromuscular layer of the proximal segment and the muscularis of the distal segment. As this suture layer is carried posteriorly it is necessary to trim off the additional excess portion of the inverted segment of rectum. When this layer has been completed, the proximal segment which has remained closed during this first portion of the anastomosis is opened by excising the staples or temporary suture line.

Up to this point the bowel lumen has not been opened. The inner layer of the

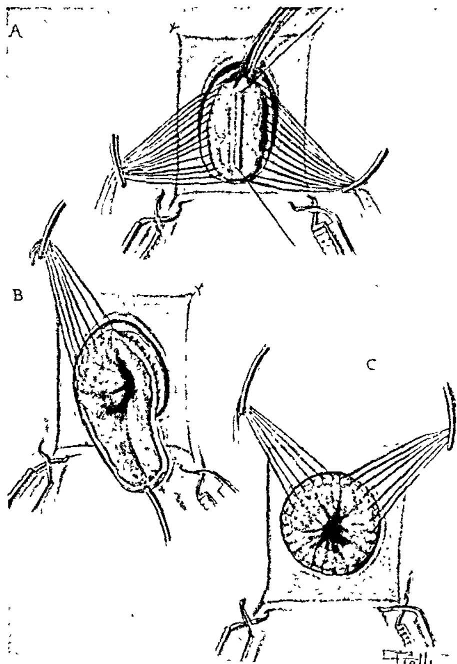


FIGURE 519. Resection of the colon for Hirschsprung's disease (*concluded*). *A*, The first or outer layer of the anastomosis has been completed, and the descending colon is being opened. *B*, The second or inner layer of the anastomosis between the mucosa is begun, using fine interrupted chromic catgut sutures. *C*, The inner layer of the anastomosis has been completed. When the sutures are cut, the anastomosis will retract into the lower pelvis. (O. Swenson and H. J. Fisher: S. Clin. North America, Vol 36.)

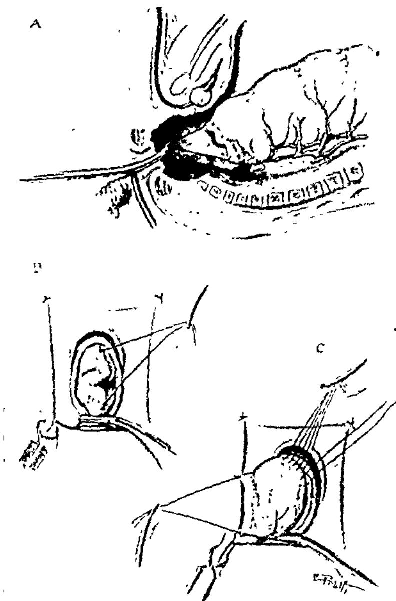


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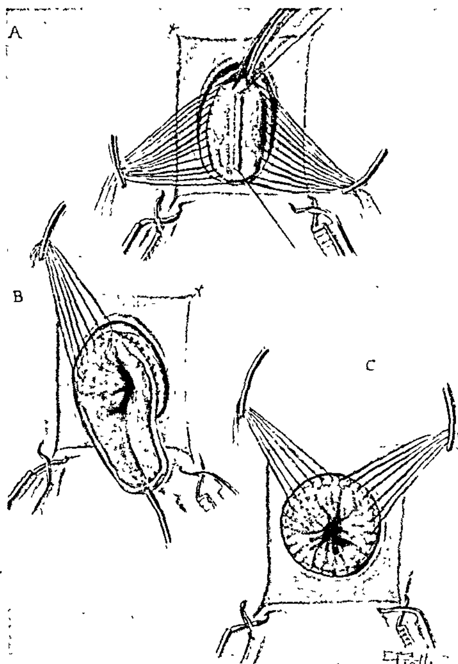


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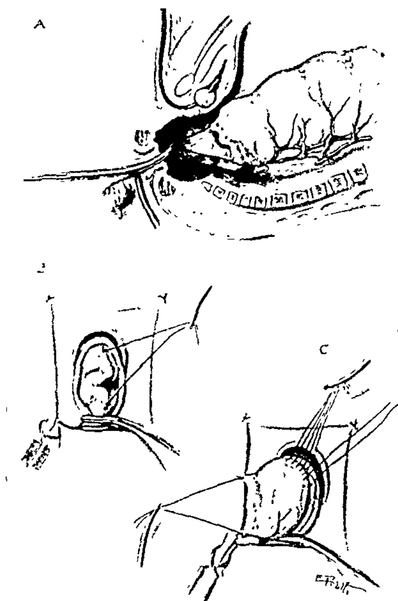


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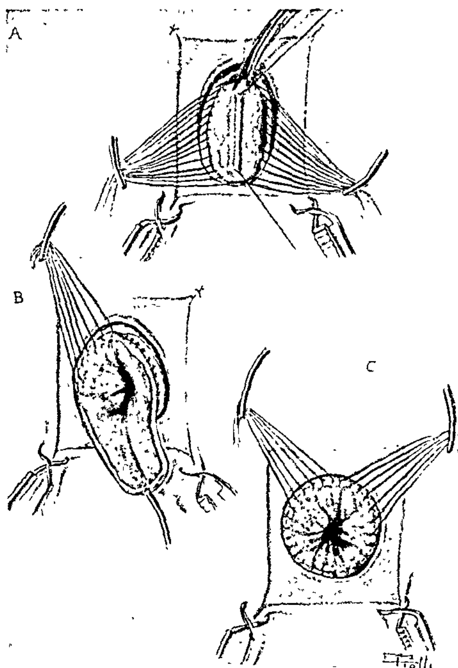


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anastomosis is then made with interrupted 5-0 chromic catgut sutures in the mucosal and submucosal layers. When this inner layer of sutures has been completed, the anastomotic line is then allowed to retract into the pelvis, and the pelvic peritoneal floor is reconstructed by the abdominal operating team. The abdominal incision is then closed in layers.

Postoperatively, nasogastric suction is continued until peristalsis returns, after which a liquid diet, gradually progressing to a full diet, is instituted. The catheter is left in the urinary bladder for approximately one week following operation.

MALFORMATIONS OF RECTUM AND ANUS

General Considerations

Anomalies of the rectum and anus are rare. They vary within wide limits from simple atresia of the anal canal to a complete absence of the anus and rectum. The rectum may end blindly, or abnormal openings from the rectum may exist in the urethra or bladder or in the vulva or vagina. The rectal or vaginal openings may form a cloaca. Fistulas extending from the rectum may terminate in the glans penis, scrotum or perineum.

Gross' classification of these cases into four types is of value in determining treatment and prognosis. Type 1: The anus and rectum are patent, but there is a stenosis either at the anus or in the rectum. Type 2: Imperforate anus with a membranous obstruction. Type 3: Imperforate anus with a blind rectal pouch ending some distance above. Type 4: The anus and lower portion of the rectum are normal, but the upper portion of the rectum ends blindly a variable distance from the lower pouch. Approximately 85 per cent of the lesions fall in the type 3 group. There is an associated fistula of some type in 71 per cent of these cases.

Considerable aid in determining the type and extent of lesion can be obtained by holding the infant in the head-down position and taking lateral and anteroposterior roentgenograms.

Treatment of type 1 lesions consists in repeated dilatation of the stricture. The simple membranous imperforate anus, type 2, is treated by cruciate incision of the membrane followed by dilatations. Treatment of type 3 lesions depends upon the distance between the anus and the rectal pouch. When the rectal pouch lies within 1.5 cm. of the perineal skin, repair is possible in most instances by the perineal operation. When the blind rectal pouch ends higher than 1.5 cm., either a proximal sigmoidostomy can be established and the defect repaired at a later date, or, in suitable cases, a combined abdominal perineal repair can be undertaken as a primary procedure. Type 4 abnormalities, of course, require a combined operation.

Technique of Perineal Operation (Ladd and Gross) (Fig. 520)

A rectal pouch which is 1 or 2 cm. above the anal skin may be freed and sutured to the perianal skin.

An incision is made in the midline extending from the scrotum or vagina backward to the tip of the coccyx. This incision divides the external anal sphincter muscles in halves. Dissection is extended through the levator ani muscles and upward around

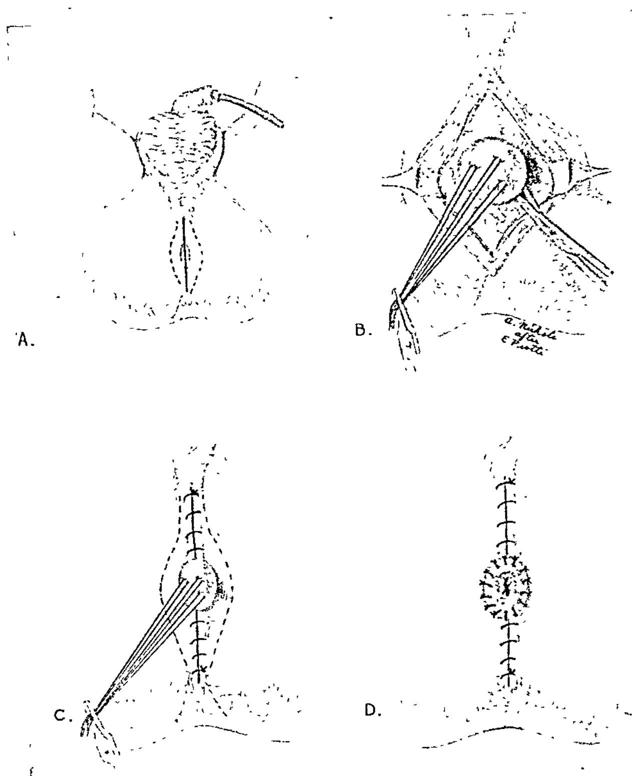


FIGURE 520. Technique of perineal operation for atresia of the rectum. *A*, The patient is in the lithotomy position with catheter in the urethra. The line of incision is indicated by the solid line, and the dotted lines show the position of the underlying anal sphincter muscle. *B*, Dissection has been completed, and the rectal pouch has been withdrawn with traction sutures. *C*, Sphincter muscle and skin have been closed anterior and posterior to the rectum. *D*, The rectal pouch has been opened, and its margins have been sutured to the perianal skin. (Redrawn from Ladd and Gross. Abdominal Surgery of Infancy and Childhood)

the rectal pouch. Injury to the male urethra, vaginal wall and rectal wall must be avoided.

After the rectal pouch has been carefully freed, traction sutures of silk are placed through its tip, and the rectum is drawn down through the wound to the skin. The sphincter muscle and skin are sutured anteriorly and posteriorly while the rectum is held in position by the traction sutures. The rectal pouch is then opened, and the margins of the opening are sutured to the perianal skin. Tension must be avoided or the stitches will cut out and the rectum will retract above the muscles, producing a stricture.

Operations upon the Anus and Perianal Area

HEMORRHOIDS

General Considerations

Hemorrhoids may be either internal (above the mucocutaneous line) or external (below the mucocutaneous line) or a combination of the two. Operations for hemorrhoids are usually designed to remove the combined internal and external hemorrhoids. External hemorrhoids are treated by incision, evacuation of clot, and removal of varicosities.

Careful preoperative preparation is essential for ease of operation and minimization of postoperative discomfort. Cathartics are rarely advisable. If the patient is to be operated upon in the morning, a cleansing enema at 4 P.M., repeated at 8 P.M., is usually sufficient. A mild sedative may be given at night and repeated before the operation. The type of anesthesia used should depend upon the nervous reactions of the patient, extent of the operation, and choice of the surgeon. Local anesthesia is satisfactory in a large percentage of cases.

Dangers and Safeguards

Ulceration and *edema* of hemorrhoids are contraindications to immediate operation. Such hemorrhoids should be treated with bed rest, warm rectal irrigations, moist packs, and sitz baths until infection and edema have subsided. Hemorrhoids may then be removed with less danger of infection and a minimal loss of anal tissue. *Rough handling of tissues*, especially by dilating the sphincter muscles, should be avoided. Excessive stretching of sphincter muscles may tear the mucosa, rupture vessels, and produce hematomas.

Excisions which may result in circular scarring of the anus must be avoided.

Strips of anal and rectal mucosa should be left intact between the wounds of hemorrhoidectomy. Injury of the sphincter muscles with resulting incontinence can only result from careless surgery. *Postoperative bleeding* will occur if vessels are not securely ligated. A large quantity of blood may collect in the rectum after operation before the patient or surgeon is aware of the hemorrhage. Although *infections* are rare, the possibility of portal vein infection with liver abscess must be kept in mind.

The results of hemorrhoidectomy should be satisfactory in 90 per cent of the cases. There may be recurrence by the formation of new hemorrhoids when all hemorrhoidal veins have not been removed. Redundant skin or *skin tabs* beyond the anal margin may follow operation, leading the patient to believe that the operation has not been complete or that there has been a recurrence. These can be avoided by proper operative technique.

Technique of Hemorrhoidectomy by Dissection and Suture Method (Fig. 521)

After induction of anesthesia the sphincter muscles are gently dilated digitally. Four Allis clamps are placed about the anal margin for traction. The hemorrhoids and skin margin are grasped with two Allis clamps. The lowest hemorrhoid is removed first to prevent subsequent annoyance from bleeding. A transfixion ligature usually of plain catgut is placed through the base of the hemorrhoid proximal to the site of

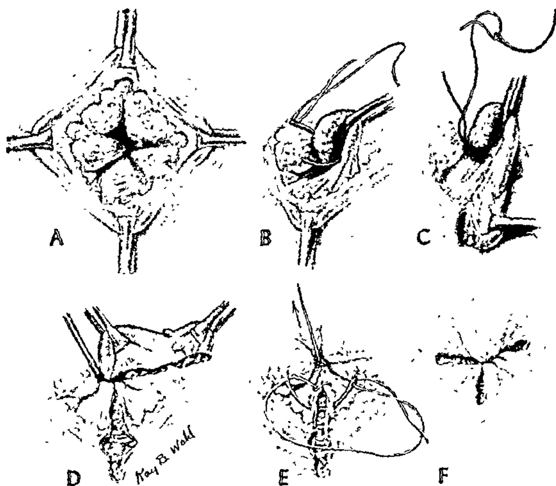


FIGURE 521. *A*, Anal orifice opened with Allis clamps. *B*, Transfixion ligature is placed. *C*, and *D*, The hemorrhoid is dissected free *E*, A few sutures unite the mucous membrane and control oozing. *F*, Final appearance of the anus

intended amputation. The skin and mucous membrane on both sides of the hemorrhoid, which is grasped in clamps, are then incised and allowed to retract. The hemorrhoid and redundant skin are then excised, dissection remaining close to the hemorrhoid in order to avoid injury to the underlying external sphincter muscle. After amputation of the hemorrhoid the resultant defect may either be left open to granulate or may be closed with a few running or interrupted catgut sutures, leaving a generous open area laterally to provide drainage and to prevent hematoma formation. A minimum amount of anal skin is removed. Wound edges may be undercut when necessary to remove dilated and thrombosed veins. The sutures should include the submucous tissues when necessary to control bleeding. Hemostasis must be scrupulous with fine catgut. Packing of the anal canal with any material is not necessary.

Postoperative Care. Small doses of morphine are indicated for pain. Warm moist compresses of physiologic saline solution are applied and renewed every few hours. A low residue diet is advised for a few days. Hot sitz baths are started on the first postoperative day and administered three or four times daily during the remainder of the hospital course. A spontaneous bowel movement usually will occur on the third to the fourth postoperative day. However, if this does not take place, assistance may be rendered by the administration of 6 ounces of mineral oil instilled into the rectum through a soft rubber catheter followed by a small saline enema. Oral cathartics of the saline variety may be given on the fourth to sixth postoperative day if necessary. The perineum should be cleansed frequently with soap and water.

Technique of Excision of External Hemorrhoids

A straight or elliptical incision is made over the swelling. Any clot present is evacuated, and thrombosed veins are excised with scissors. Bleeding is controlled and the wound sutured with plain catgut. A hematoma may form if vessels are not ligated or included in deep stitches which close the skin.

EXCISION OF FISTULA IN ANO

General Considerations

Anal fistulas may be pyogenic or tuberculous in origin. Excision is usually the best treatment in either type. As fistulas arise from infection entering the perianal and perirectal areas at the mucocutaneous line through the crypts of Morgagni, the internal openings will usually be found along this line between the sphincters. The locations of the openings vary, but are most frequently found in the midline posteriorly. The fistulous tracts may be multiple, extensive and extremely tortuous.

Dangers and Safeguards

The chief danger of operation is the loss of sphincter function. Heavy scars resulting from extensive operations may cause anal strictures. To avoid complications and to ensure the highest percentage of cures, David suggests the following principles: (1) Adequate drainage of pus, allowing the tissue to return to normal and sinuses to become as small as possible before radical operation for cure of the fistula is attempted. (2) Multiple operations in extensive complicated fistulas which allow much of the

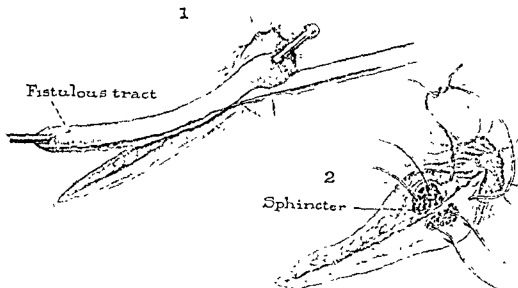


FIGURE 522. Excision of simple fistula in ano. *1*, Probe passed through fistula as a guide for excision of the entire tract. *2*, When all fibers of the external sphincter are cut, mattress sutures are placed to unite the deepest portions of the muscle to prevent retraction of the ends. (David· Lewis' Practice of Surgery, Vol. VII, W. F. Prior Co., Inc.)

soft parts to heal before the bowel is opened. (3) Except in the posterior raphe, both sphincters are never cut without their reconstruction at the end of the operation. When the whole body of the external sphincter is cut, except in its coccygeal extension where it is splinted and prevented from retracting, it is always best to partially suture the muscle ends. (4) Tight packing should be avoided. (5) Careful after-treatment is *essential to keep the wound clean, provide adequate drainage, and ensure healing of* the wound from the bottom.

Lockhart-Mummery states that a bad case of fistula in ano is one of the surgeon's most difficult problems. Each case must be carefully studied and a suitable operation planned. All fistulous tracts should be opened widely and made to communicate with each other to form an open wound. Tracts may be traced with a finger in the rectum by palpating the thickened tissues. There is frequently a deep cross tract behind the anal canal, which, if undetected, will prevent healing. All unhealthy tissue and overhanging skin should be cut away. If the skin edges and diseased tissue are all cut away, packing of the wound is unnecessary. The wound should be left wide open. If *the fistula is extensive, it should be operated upon in two stages. In the first stage* all diseased tissue should be excised down to the sphincter muscle. If the muscle is divided, the ends will retract and produce incontinence. After two or three weeks the muscle ends will be firmly held by scar tissue, and the muscle may be divided with little danger of retraction of the cut ends.

The wound should be carefully watched for collections of pus, and any pockets which form should be opened and drained. Sitz baths should be taken once or twice daily during the healing period. Application of antiseptics is contraindicated. A dressing of coarse gauze against an extremely sensitive perineum is uncomfortable for the atient in his postoperative phase. A satisfactory highly absorbent dressing can be epared *from soft cellulose cleansing* tissues to form a compress for application to the ·rineum. After brief instruction the patient can prepare and reapply these dressings vhen needed without requiring assistance.

Technique (Fig. 522)

General, sacral or spinal anesthesia is satisfactory. The sphincter muscles are gently stretched and the fistulous tract located by carefully passing a probe from the internal to the external opening. This cannot always be done because of the tortuosity of the tract. The tract is opened and excised throughout its length when possible. The external sphincter may be partially or completely cut, but no portion of it should be excised. It is often possible to excise a fistula by grasping the opening of the fistulous tract in an Allis forceps, making a generous elliptical skin incision, and "coning out" the entire tract down to its source of origin in the rectum, passing between the sphincter muscles without disturbing their function by division. After the tract has been excised down to its opening in the anal canal the sphincter is reconstructed with catgut sutures if necessary. The wound should be packed loosely with iodoform or petrolatum gauze to be removed in four to five days. Hot sitz baths and careful cleansing of the

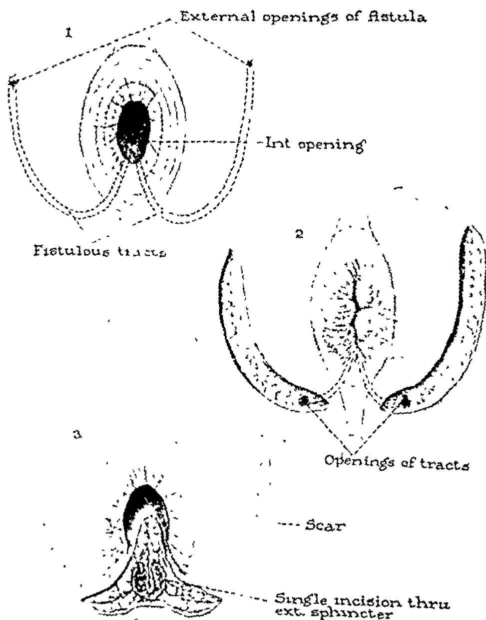


FIGURE 523. Excision of horseshoe fistula in ano. Internal opening on posterior wall of rectum. *1*, Outline of fistulous tracts. *2*, First-stage *operation*. *Lateral* tracts opened on each side to near sphincter muscle *3*, Second-stage operation after first stage has healed Fistula excised into rectum. Sphincter cut in one plane (David: Lewis' Practice of Surgery, *Vol. VII*, W. F. Prior Co , Inc.)

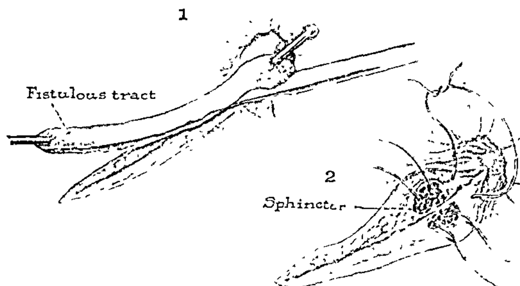


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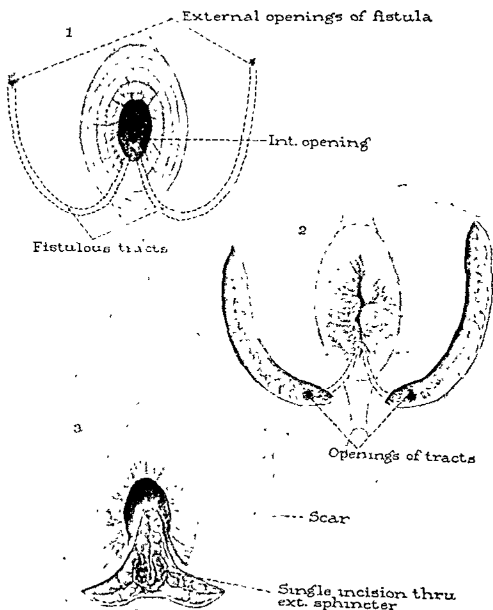


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wound are necessary for prompt healing with a minimum of scar tissue. Excessive wound packing causes excessive scar tissue. The bowels may be moved within three days and kept soft with daily doses of mineral oil until the wound is healed. A sitz bath or careful cleansing is advisable after each bowel movement.

Extensive fistulas may be operated upon in multiple stages, leaving closure of the opening into the rectum for the last operative procedure (Fig. 523). Ramifications are excised and the wounds permitted to heal before the origin of the fistula is excised. If the internal opening is above the internal sphincter muscle, the surrounding mucosa may be freed downward and sutured to close the defect as described by Elting. The fistulous tract is excised and packed lightly with gauze.

CHRONIC FISSURE IN ANO

Technique of Excision (Fig. 524)

The sphincter muscles are gently stretched and the anal margins retracted to expose the full length of the fissure-ulcer. A hooked probe is used to explore under-

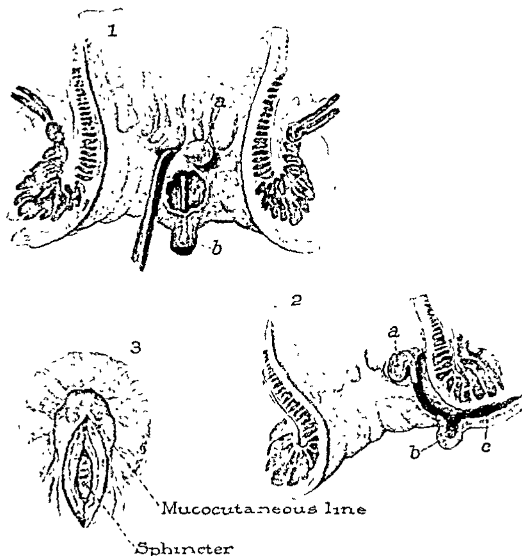


FIGURE 524. Excision of chronic fissure in ano 1, A hooked probe is passed through crypt along tract of fissure: a, inflammatory fibrous polyp; b, "sentinel pile" near end of blind tract. 2, Cross section through tract and ulcer. a, polyp at internal opening; b, "sentinel pile", c, continuation of blind fistula beneath skin. 3, Defect left after excision of tract and ulcer, exposing sphincter muscle (David: Lewis' Practice of Surgery, Vol. VII, W F Prior Co, Inc.)

mining of the anal mucosa. The mucosa and skin surrounding the fissure are excised, and granulation tissue is removed down to the sphincter muscle. The fibrous skin tab or "sentinel pile," frequently present, should be completely excised. An opium suppository may be placed in the rectum at the end of the operation. Hot sitz baths may be begun on the operative day or first postoperative day, and repeated as required.

After the operation warm moist compresses are used, to be renewed every few hours. Small doses of morphine are indicated if there is postoperative pain. After the second day the bowels should be moved by an oil enema of 60 to 120 cc. followed by a small saline enema introduced through a soft rubber catheter.

PERIANAL ABSCESS

Technique of Incision

Perianal or perirectal abscess is an exquisitely painful condition arising from infection of the crypts of Morgagni. These will frequently drain spontaneously and usually develop into a fistula in ano. Proper incision and drainage may minimize the possibility of development of this relatively refractory condition. Consistent with the general principle of radial incisions in the perineal region, incision is made over the apex of the pointing perianal abscess, and a generous ellipse of skin over the top is excised. This is done in order to allow the most efficacious drainage possible and to permit healing by granulation from the depths of the abscess. A small iodoform-impregnated gauze wick may be used as a pack if desired. The postoperative care is identical with that given to the patient who has had a hemorrhoidectomy.

ISCHIORECTAL ABSCESS

Technique of Incision and Drainage

These abscesses originate in the crypts of Morgagni between the two anal sphincters and develop in the perianal and perirectal structures. To avoid destruction of tissue and extension upward into the pelvis, an ischiorectal abscess should be incised and drained early. A general anesthetic is advisable.

An incision is made over the abscess in a radial manner over the fluctuant area. The external sphincter must be preserved. After the abscess cavity has been entered and the pus evacuated, digital exploration must be done to open pockets which might otherwise not be thoroughly drained. If the abscess has extended above the levator ani muscles, a finger inserted into the rectum will help guide the tip of a blunt hemostat into the pelvirectal space. In such an event a Penrose drain should be left in the depths of the abscess cavity and the remainder packed loosely with iodoform or petroleum gauze which may be removed in four or five days. After removal of the packing hot sitz baths and irrigations may be instituted; 1:10,000 solution of potassium permanganate instilled through a soft rubber catheter once or twice daily is occasionally of great help in the toilet of these abscess cavities.

PRURITUS ANI

General Considerations

Pruritus ani should generally be treated conservatively without operation. Removal of all anal and rectal pathologic conditions and elimination of intestinal para-

sites and of irritating rectal and vaginal discharges by the use of local applications or alcohol injections, will effect a cure or give relief in a high percentage of cases. *Operation should be reserved for the severe intractable cases which have resisted non-operative therapy.*

Technique of Alcohol Injection Treatment (Stone) (Fig. 525)

A gas or low spinal anesthetic is satisfactory. The field of operation is thoroughly cleansed with soap and water. Pure 95 per cent grain alcohol is used for injection. A small tuberculin syringe with a short, fine hypodermic needle is recommended so that small measured quantities of alcohol may be injected. The needle is thrust through the skin in a vertical position. From 2 to 4 minims of alcohol are used for each injection. *The needle punctures are made 0.5 cm. apart, and the entire area involved in* the pruritus is "stippled." Injections are made within 0.5 cm. of the anal canal, but not within the canal. If the scrotum, labia, or folds of the buttocks are involved, they may be injected in the same manner.

The danger of sloughing of the skin is slight if the quantity of alcohol used is not excessive or is not injected into the skin. The immediate results are good, with freedom from symptoms from a few months to several years. Injections for recurrence of symptoms may be repeated as often as necessary.

Technique of Buie (Fig. 525)

Forty per cent alcohol is used for injection. A long needle of about size no. 20 is used. One perforation on each side of the anus at the margin of the area of pruritus is usually sufficient. The alcohol is injected beneath the entire area involved. The injec-

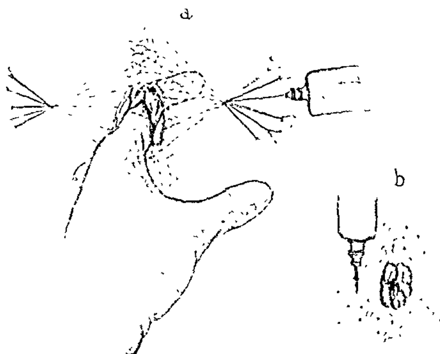


FIGURE 525 Technique of alcohol injection for pruritus ani *a*, Buie's method of alcohol injection After dilatation of the anus the subcutaneous tissues of the involved area are injected with 40 per cent alcohol. *b*, Stone's technique of alcohol injection *Multiple punctures of the skin are made throughout the involved area*, and 2 to 4 minims of 95 per cent alcohol are used for each injection (Swinton S Clin. North America, Vol 19)

tion is made between the skin and muscle. If the alcohol is injected into the skin, sloughs may occur, and if injected into the muscle, abscesses may develop.

Care must be used to inject the alcohol evenly beneath the skin. If involved areas are missed, itching may not be completely relieved. Swinton advises preliminary dilatation of the anus to smooth out the folds and rugae of the adjacent skin. Unnecessary trauma, producing breaks in the skin, should be avoided to prevent leakage of the alcohol. Injection should not be made beyond the mucocutaneous line.

Sloughing or infection may result after the alcohol injection treatment. Moist dressing should be applied to the perineum after the treatment, and sitz baths may be started in two or three days.

Technique of Lynch (Fig. 526)

An incision 1 cm. long is made on each side of the anus about 3.5 cm. from the anal margin. Through these incisions the skin is undermined about the anus, completely severing sensory nerve filaments which supply the affected area. Bleeding is usually controlled by pressure. Small rubber tissue drains may be used for twenty-four hours. Sutures are seldom necessary.

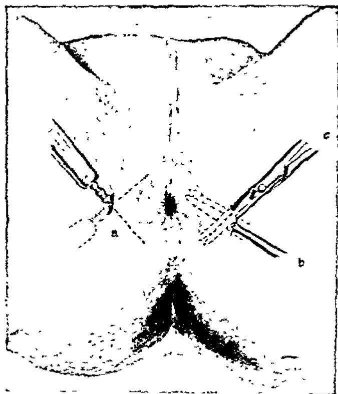


FIGURE 526. Lynch's operation for pruritus ani. *a*, Local anesthesia is introduced through a small incision. *b*, Margin of incision is steadied with Allis clamp. *c*, Subcutaneous tissues are severed about the anus to divide nerve supply to the skin. (Bickham: Operative Surgery, Vol. V.)

Technique of Ball (Fig. 527)

A lateral curved incision is made on each side of the anus 2.5 to 3.5 cm. from the anal margin. Sections of skin at the anterior and posterior median raphe 1 cm. wide are left intact. The skin is then undermined with scissors inward to the mucocutaneous line in the anal canal and outward 2.5 cm. from the margins of the skin separating it from its subcutaneous nerve fiber connections.

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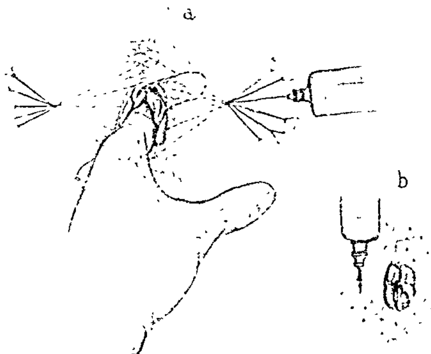


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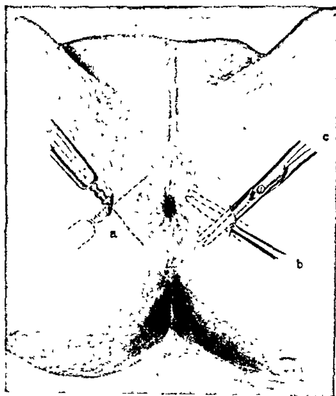


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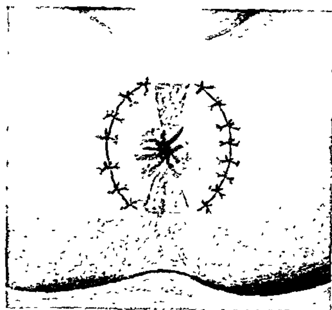


FIGURE 527. Ball's operation for pruritus ani. Skin flaps are raised on each side of anus to sever the cutaneous nerve supply. The anterior and posterior bridges shown in shaded areas are not undermined Flaps are sutured in place. (Bickham: Operative Surgery, Vol. V.)

ANAL INCONTINENCE

Technique of Plastic Operation (Wreden-Stone) (Fig. 528)

Autogenous fascial strips are cut from the patient's fascia lata. They should be *removed as the first step in the operation and placed in salt solution* until ready for use. The strips are made 1 cm. wide and from 22 to 25 cm. long.

The patient is placed in the exaggerated lithotomy position. Two symmetrical incisions are made, one on each side, about 4 cm. lateral and slightly posterior to the anal margin. These incisions are made about 2 cm. long and are parallel with the *margins of the gluteus maximus muscle*. A long, curved clamp is passed by blunt dissection from one incision to the other anterior to the anus. The ends of the two strips of fascia previously prepared are grasped with the clamp and drawn through the tunnel. The clamp is then passed in the opposite direction posterior to the anus, carrying an end of one fascial strip. This completes the loop of one strip of fascia. One end *of the second strip of fascia is drawn through the tunnel posterior to the anus*, which completes the second fascial loop encircling the anus.

The margins of both gluteal muscles are freed, and bundles of muscle about as thick as the index finger are separated. One end of the fascial strip is passed about this muscle bundle on each side and tied. Enough tension is placed on the fascia to close the anus snugly. *The cut ends of the fascia may be fixed* with fine silk sutures. The small skin incisions are closed and sealed with some protective dressing such as collodion.

By this operative procedure the anus is encircled by two loops of fascia running in opposite directions and tied under some tension about bundles of the gluteus maximus muscle. When the glutei are voluntarily contracted, they pull the fascial loops tighter, increasing the voluntary closing pressure of the anal canal. Patients should be taught the importance of this mechanism before they are discharged from the hospital.

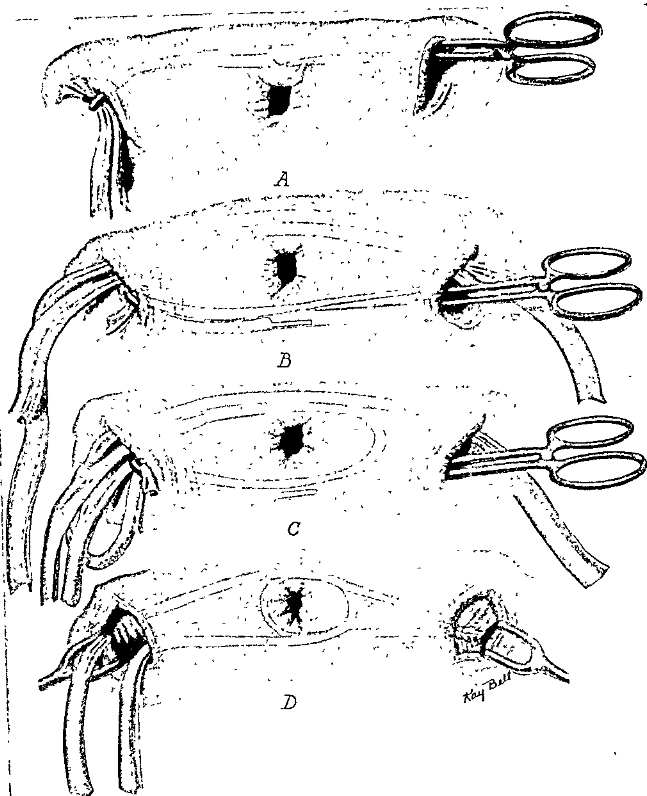


FIGURE 528 Plastic operation for anal incontinence *A*, Curved clamp passed in front of anus, grasping strips of fascia lata to be drawn through to opposite side. *B*, Strips of fascia are passed subcutaneously in front and behind anus. *C*, The loops of fascia encircle the anus subcutaneously in opposite directions *D*, A bundle of gluteus maximus muscle is separated on each side The fascial strips are passed around these muscle bundles and tied and sutured with enough tension to close the relaxed anus. (Redrawn from Stone: Arch. Surg.)

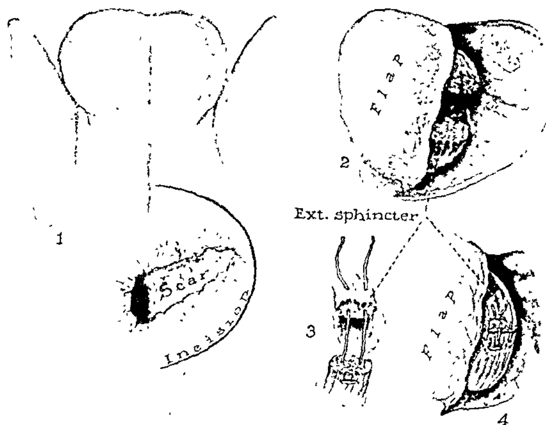


FIGURE 529 Repair of divided anal sphincter. *1*, Scar from extensive operation for fistula in ano resulting in incontinence. Line of incision outlines a flap consisting of skin, superficial fascia and fat *2*, Flap dissected up, exposing divided sphincter. *3*, Mattress sutures are used to unite the divided ends of the sphincter. *4*, Suture of sphincter completed. (David Lewis' Practice of Surgery, Vol. VII, W F Prior Co , Inc.)

Technique of Operation for Incontinence Due to Divided Sphincter Ani Muscle (David) (Fig. 529)

A plastic operation for the repair of a divided sphincter ani muscle should be successful if injury or infection has not destroyed too much of the muscle.

A semicircular incision is made beyond the scar when possible. A flap of skin and subcutaneous tissue is reflected toward the anus, and the ends of the sphincter muscle are exposed by carefully dissecting away the scar tissue. The muscle ends are united with mattress and interrupted chromicized catgut sutures.

The flap of skin and subcutaneous tissue is replaced and sutured.

SACROCOCCYGEAL (PILONIDAL) CYSTS AND SINUSES

General Considerations

Acute infections of pilonidal cysts should be incised and drained. After the acute infection has subsided the cysts with all sinus tracts may be approached with definitive surgery. There may be multiple sinus openings in the midline over the sacrum or over the folds of the buttocks. Occasionally sinuses may extend to the perineum and be mistaken for fistulas in ano. Injection of the sinus tracts with a dye such as methylene blue may rarely be of assistance in their identification at the operating table. This is

usually unnecessary and many times results in an over-all discoloration of the operative field which is undesirable and often confusing.

Dangers and Safeguards

Much experience was gained with this disease in World War II in the military services. It is the consensus of most surgeons that the method which will produce the highest cure rate with a single operation is that of excision and secondary healing. However, this process is extremely slow; therefore several methods have been devised which are intended to shorten the period of healing. These are (1) primary closure, (2) marsupialization, and (3) partial closure. Primary closure should be reserved for the minimal noninfected lesion.

Technique of Excision with Primary Closure (Fig. 530)

The patient is placed on his abdomen with his hips slightly elevated. An elliptical skin incision is made about the midline sinus. If there are lateral sinuses, lateral incisions should be made from the primary incision. The cyst and all sinuses are completely dissected out. If a portion of the sinus tract is left, there will be a recurrent sinus formation. The skin is closed with vertical mattress sutures of silk which approxi-

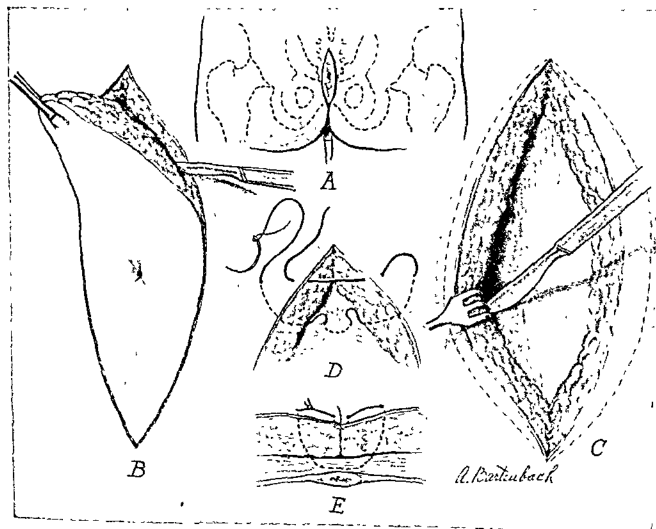


FIGURE 530 Excision of pilonidal cyst and sinus. *A*, Incision about sinus opening. *B*, Section of skin and subcutaneous tissue removed down to sacral fascia. *C*, Undercutting flaps over gluteal muscles. *D*, On-end mattress suture being placed Suture grasps fascia over sacrum. *E*, Section showing position of suture when tied.

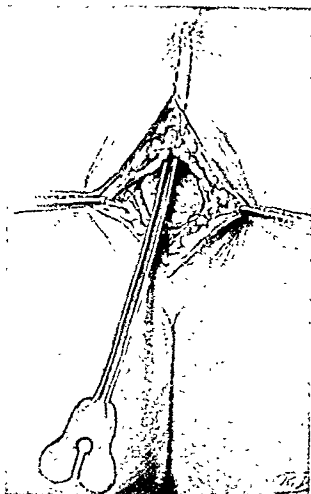


FIGURE 531. Incision of pilonidal sinus over a grooved director. (L. A. Buie and R. K. Curtiss: S. Clin. North America, Vol. 32)

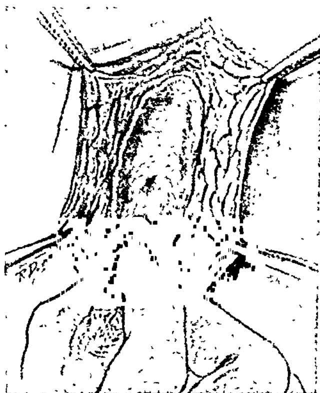


FIGURE 532 Wall of the abscess has been unroofed and scrubbed, revealing a secondary tract (L A Buie and R. K. Curtiss· S. Clin. North America, Vol 32.)

mate the wound margins and obliterate dead space. A drain is usually not necessary. A pressure dressing completes the operation. If removal of the sinus tract is complete, healing per primam may be expected in a large percentage of cases. Recurrence is not uncommon.

Technique of Marsupialization (Buie)

A probe or grooved director is inserted into the sinus tract and the skin incised over the probe or director (Fig. 531). If subsidiary sinuses are found, each is incised and laid wide open in a similar manner. These are then scrubbed with gauze sponges and all debris and granulation tissue removed (Fig. 532). The external and lateral walls of the cysts and sinuses are excised, and the skin edges are sutured to the remain-

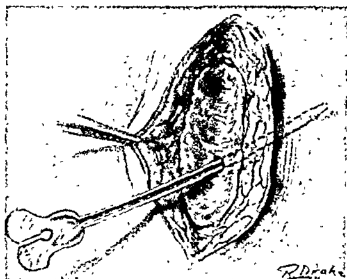


FIGURE 533. Grooved director inserted into secondary tract. (L. A. Buie and R. K. Curtiss: S. Clin. North America, Vol. 32.)



FIGURE 534. The skin edges are trimmed to fit the edges of the cyst wall. (L. A. Buie and R. K. Curtiss S. Clin. North America, Vol 32.)

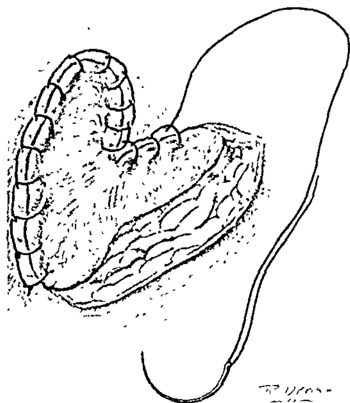


FIGURE 535. Suture of the skin to the remaining cyst wall. (L A. Buie and R. K. Curtiss: S. Clin. North America, Vol. 32.)

ing margins of the wall of the cysts or sinuses (Figs. 534, 535). A petrolatum gauze dressing is applied and changed when indicated. The sutures, which are usually of a nonabsorbable variety, should be removed on the eighth postoperative day. No restriction of ambulation or diet is necessary.

Technique of Partial Closure (MacFee)

After the usual skin preparation and draping of the sacrococcygeal area the lesion is excised en bloc down to the sacrococcygeal fascia. The skin is then some-

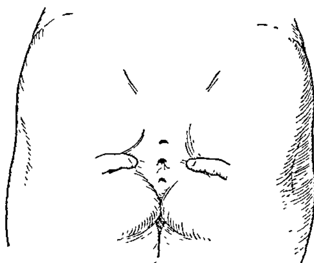


Fig 536.

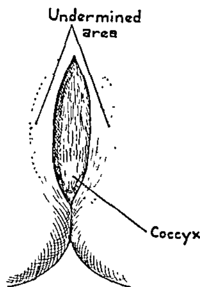
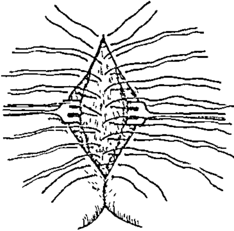
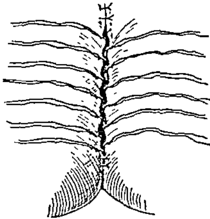


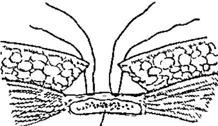
Fig. 537.

FIGURE 536 Appearance of typical pilonidal cyst. (W A MacFee: Ann. Surg, Vol. 116.)

FIGURE 537. The lesion is excised en bloc and the skin undermined (W. A MacFee. Ann. Surg, Vol 116)







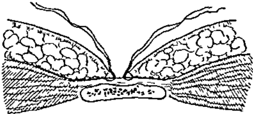


Fig 538

Fig. 539.

FIGURE 538 Placement of skin sutures through postsacral fascia. (W. A. MacFee. Ann. Surg., Vol. 116.)

FIGURE 539. Sutures are tied approximating the skin to fascia, and the ends left long. (W. A. MacFee: Ann. Surg., Vol 116)

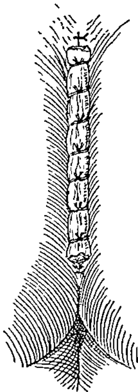


FIGURE 540 A gauze pledget is tied with the long end of the skin sutures to act as a wet dressing for the absorption of serum. (W. A. MacFee· Ann Surg., Vol 116.)

what undermined (Fig. 537), and the skin margins are sutured to the postsacral fascia, using *interrupted sutures of nonabsorbable material* (Figs. 538, 539). This leaves only a narrow surface of fascia to heal by secondary intention. A small dressing roll of gauze is then tied in place over these sutures (Fig. 540). Hot sitz baths may be started on the first postoperative day. The sutures may be removed in ten to twelve days.

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CHAPTER 14

Hernia

OPERATIONS FOR INDIRECT INGUINAL HERNIA

Anatomy

Since an indirect inguinal hernia passes through the inguinal canal, it is necessary that the essential embryological and anatomical features of this canal, with its surrounding structures, be famil-

iar to the surgeon. The testicle passes through the canal in embryonic life and carries with it the processus vaginalis peritonei. The persistence of this structure, in whole or in part along the spermatic cord, results in the potential sac into which protrude abdominal viscera to form a hernia. The inguinal canal extends from the internal to the external abdominal ring.

Anterior to the inguinal canal are the skin, superficial fat and fascia, and the aponeurosis of the external oblique muscle. Near the pubic bone the strong fibrous sheet of the aponeurosis divides to form the upper and lower columns of the external inguinal ring. The upper column is attached to the crest of the symphysis pubis and the lower to the spine of the pubis. The latter is continuous with the inguinal (Poupart's) ligament. Between the columns is the intercolumnar fascia, which forms a thin covering of a hernia passing through the external ring. The average normal external inguinal ring will not completely admit the tip of the fifth finger. The ring in certain patients may be more than 2 cm. in diameter without a demonstrable hernia.

The internal inguinal ring is located midway between the anterior superior spine of the ileum and the spine of the pubis. It is an oval opening in the transversalis fascia bounded by the arching borders of the internal oblique and transversalis muscles above and external, by the deep epigastric vessels medially, and below by Poupart's ligament.

The inguinal canal is about 4 to 5 cm. long in the adult. It begins at the internal ring and ends at the external ring. It contains the spermatic cord, inguinal branch of the ilio-inguinal nerve, the genital branch of the genitocrural nerve, the processus vaginalis peritonei or its cordlike obliterated remains, the infundibuliform fascia, and cremaster muscles. The spermatic cord proper contains the vas deferens and spermatic vessels. If a hernial sac is present, it lies in direct contact with the cord and anterior to the cord. The hypogastric branch of the iliohypogastric nerve lies above the cord on the surface of the internal oblique muscle and pierces the external oblique aponeurosis just above the external abdominal ring.

The inguinal canal is bounded throughout its length in front by the aponeurosis of the external oblique and at its outer end by the lower portion of the internal oblique muscle. The posterior wall is formed by the transversalis fascia, conjoined tendon and triangular ligament. Bounding it above are the internal oblique and transversalis muscles, and below are Poupart's ligament and Gimbernat's ligament.

The cremaster muscle surrounds the cord and continues with it into the scrotum. It originates from the lower fibers of the internal oblique muscle, which become thinned out over the cord. With the muscle covering the cord is the cremasteric fascia. This muscle and fascia form a structure which is so attentuated that it is of little practical value as an aid in the plastic operation for hernia repair.

The coverings of an indirect inguinal hernia from within outward are peritoneum, properitoneal fat (if present), infundibuliform fascia, cremaster muscle and fascia, intercolumnar fascia, superficial fascia and skin.

Dangers and Safeguards

There are six essential structures that may be injured during the repair of an inguinal hernia: (1) the two inguinal nerves; (2) the cord structures; (3) the contents of the hernial sac; (4) the femoral vessels; (5) the deep epigastric vessels; and (6) the

bladder. As the operation proceeds, it is necessary that these structures be identified and protected. The cremaster muscle and fascia are separated from the cord to avoid bulkiness of this structure which might predispose to recurrence of the hernia. Approximation of suture lines must be carefully made to prevent fat, fascia or muscle from protruding between the sutures to interfere with sound healing. To facilitate closure, a portion of the cremaster muscle and protruding properitoneal fat may be cut away. When repairing a direct hernia or large indirect hernia, the floor of the inguinal canal must be reconstructed down to the pubic bone. A bulky bundle of cremaster muscle at the lower end of the suture line will prevent snug closure.

Technique of Operation for Indirect Inguinal Hernia (Modified Bassini Method) (Fig. 541)

The skin incision extends from a point external to the internal inguinal ring about 3 cm. above Poupart's ligament to a point over the external ring at the pubic spine. For an adult the average length of the incision necessary for good exposure is approximately 10 cm. The fat and subcutaneous tissues are incised, exposing the aponeurosis of the external oblique and the external inguinal ring. At this stage of the operation all bleeding vessels should be carefully ligated and the margins of the wound draped with towels.

The external oblique aponeurosis is opened the length of the skin incision on a line with the upper margin of the external ring. This is done by beginning the incision in the external end of the wound and extending it carefully inward. The nerves and hernial sac beneath may be protected by separating the aponeurosis from the underlying structures with scissors and by lifting the cut margins of the aponeurosis as the incision progresses.

The lower aponeurotic flap is separated from its underlying tissues with blunt dissection, exposing the shelving portion of Poupart's ligament down to the pubic spine. The upper flap is dissected back, exposing the internal oblique muscle and conjoined tendon area and the ilio-inguinal and iliohypogastric nerves. To protect the latter nerve, it may be freed from the internal oblique muscle to its opening in the aponeurosis and retracted out of danger.

The cremaster muscle is incised throughout the length of the inguinal canal, exposing the hernial sac and spermatic cord. The muscle and overlying fascia are stripped from the sac and cord by blunt and sharp dissection The sac lies anterior to the cord and is recognized as a white membrane. It is grasped with forceps and separated from the cord by sharp and blunt dissection If there is any doubt about the size and extent of the sac, it should be opened and examined from the inside. By passing the finger through the indirect sac, careful exploration is made for direct and femoral hernias If such a hernial sac is found, it is withdrawn beneath the inferior epigastric vessels and converted to a part of the indirect sac by the method of Hoguet. Adhesions within the sac are divided and ligated when necessary. The sac is separated from the cord up to the peritoneum, where it is transfixed, ligated and removed. The neck of the sac is ligated as high as possible to avoid any outpouching of the peritoneum. Large sacs may require multiple sutures to close.

The cord is carefully freed of all fascia and muscle from the internal ring to the pubic bone and held aside with a tape loop. The transversalis fascia is sutured to

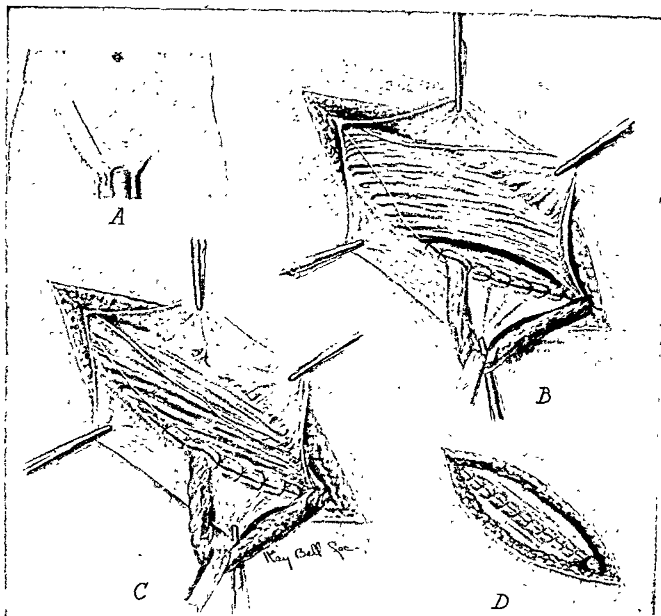


FIGURE 541 Technique of the Bassini operation for indirect inguinal hernia. *A*, Line of incision. *B*, Cord transplanted and transversalis sutured to the inguinal ligament lateral and medial to the cord. This closes the internal ring. Ilio-inguinal and iliohypogastric nerves identified to prevent injury. *C*, Internal oblique sutured to inguinal ligament. *D*, Aponeurosis of external oblique closed.

Poupart's ligament with interrupted sutures. One to three sutures are placed lateral to the cord to close the internal ring around this structure. A tight closure about the cord should be avoided. The remaining cremaster muscle and fascia may be pushed into the bed of the inguinal canal beneath the transversalis, or a portion of the cremaster may be cut away to permit a smoother closure. The internal oblique muscle and its fascia are sutured to the shelving portion of Poupart's ligament over the transversalis suture line both medial and lateral to the cord. One or two sutures should pass through the conjoined tendon to approximate this structure to the insertion of Poupart's ligament firmly against the pubic bone. Protruding fat lying in contact with the proximal portion of the cord should be removed Avoid including the inguinal nerves in sutures

The spermatic cord is placed in the canal on the surface of the internal oblique muscle, and the aponeurosis of the external oblique is closed over the cord with interrupted sutures. The newly formed external ring must be left large enough for the

passage of the cord without constriction. The superficial fascia should be closed with a few deeply placed fine sutures. The skin is closed with silk.

The use of silk or cotton suture is recommended in hernia repair in appropriate sizes ranging from 00 to 0000.

Technique of Operation for Indirect Inguinal Hernia in Infants

The technique of hernia repair in infants and children is shown in Figures 542, 543, 544. The tissues are delicate and require careful dissection to avoid injury to the structures of the spermatic cord and tearing of the sac. The external abdominal ring must not be made too tight. The Ferguson technique is modified by suturing the aponeurosis of the external oblique and the internal oblique muscles together to the inguinal ligament with three or four fine silk sutures. If the sac is continuous with the tunica vaginalis, that portion around the testicle may be left. There is no age limit for

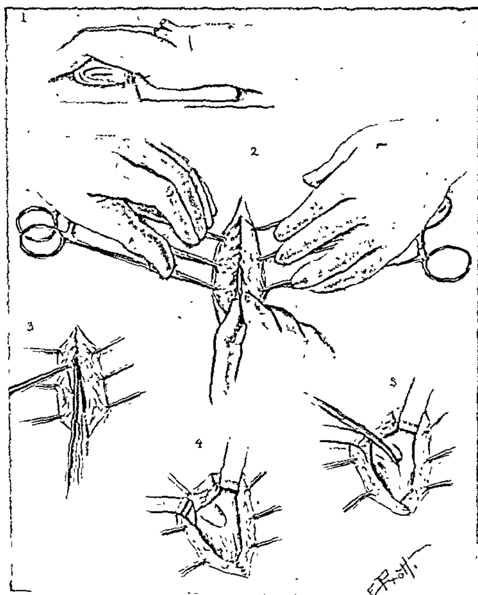


FIGURE 542. Technique of repair of indirect inguinal hernia in the child. *1*, Position of child on the operating table. Line of incision in crease of skin. *2 and 3, Incision in skin, subcutaneous tissues and* superficial fascia, aided by traction with hemostats. Careful hemostasis is important. *4*, External oblique aponeurosis and external abdominal ring *exposed. 5, External oblique* aponeurosis being split upward and outward parallel with its fibers. (Gross: The Surgery of Infancy and Childhood.)

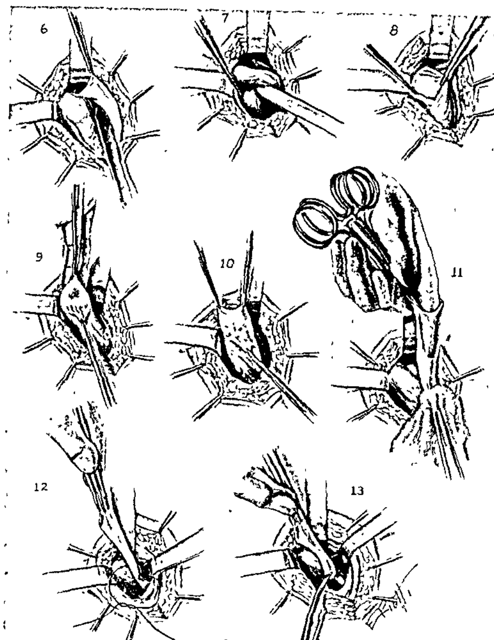


FIGURE 543. Technique of repair of indirect inguinal hernia in the child (*continued*) *6*, Upper peak of external oblique aponeurosis *7*, Lower flap of external oblique aponeurosis is being freed to expose the inguinal ligament *8*, The cremaster muscle and fascia have been incised to expose the hernial sac and spermatic cord. *9* and *10*, The sac is held with a hemostat while it is being carefully separated from the cord with sharp and blunt dissection *11*, Sac opened and held with hemostats A finger inserted into the sac aids blunt dissection so as completely to expose its neck. *12*, The neck of the sac has been transfixed and is being ligated with a silk suture. *13*, The sac being cut away (Gross: The Surgery of Infancy and Childhood.)

the repair of hernias in infants and children. The repair of an inguinal hernia in an infant should be done as soon as the baby has achieved a stable metabolic balance, since strangulation is a frequent complication. Bilateral hernias may be repaired simultaneously in healthy children.

Technique of Repair of Small Indirect Inguinal Hernia

The anatomy is illustrated in Figure 545.

The hernial sac is exposed and removed as in the Bassini type of operation (Fig. 546). After the sac has been removed the defect in the transversalis fascia is closed,

using interrupted sutures approximating the edge of the transversalis fascia to the femoral sheath (Figs. 547, 548). A relaxing incision is usually unnecessary. The external oblique fascia is then approximated with interrupted sutures of fine nonabsorbable material, usually no. 000 in size, with some attention paid to careful reconstruction of the external inguinal ring to a normal size. The subcutaneous tissues are then closed with a few interrupted sutures of no. 0000 nonabsorbable suture material and the skin in whatever manner that may be chosen by the surgeon.

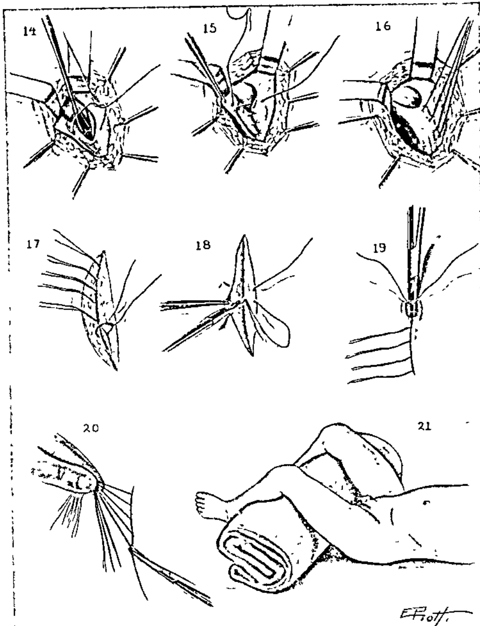


FIGURE 544. Technique of repair of indirect inguinal hernia in the child (*concluded*) *14* and *15*, External oblique aponeurosis and internal oblique muscle being sutured to the inguinal ligament over the cord with interrupted sutures of fine silk To avoid making the external abdominal ring too tight, the most medial suture is passed through the under surface of the external oblique aponeurosis instead of the inguinal ligament. *16*, The lower flap of external oblique aponeurosis is imbricated over the upper flap with interrupted sutures of fine silk. *17*, The superficial fascia is being closed with interrupted sutures of fine silk. *18*, The skin is approximated with number 5-0 silk which grasps the corium *19*, Method of holding back subcutaneous fat with a hemostat while the skin sutures are being tied. *20*, Subcuticular sutures are cut close to the knot so that ends of suture will not protrude through the incision. *21*, A collodion dressing is applied to the wound, and the knees are held in flexion over a roll of blanket until the collodion is dry (Gross. The Surgery of Infancy and Childhood)

Fig. 545.

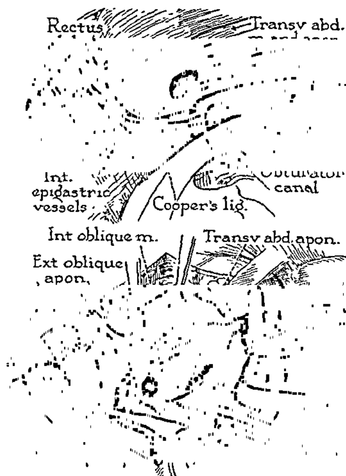


Fig 546.

FIGURE 545. Anatomy of small indirect inguinal hernia. (C. B McVay: Hernia. Springfield, Ill , Charles C Thomas, 1954.)

FIGURE 546. High ligation of the sac with delineating of the defect in the transversalis fascia (C B. McVay: Hernia. Springfield, Ill , Charles C Thomas, 1954)

Fig. 547.

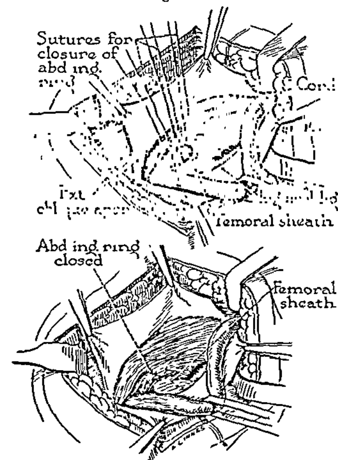


Fig. 548.

FIGURE 547. Closure of defect in transversalis fascia in small indirect hernia (C. B. McVay. Hernia. Springfield, Ill., Charles C Thomas)

FIGURE 548. Completion of closure shown in Figure 547. (C. B McVay· Hernia. Springfield, Ill , Charles C Thomas.)

THE USE OF GRAFTS IN THE REPAIR OF INGUINAL HERNIA

General Considerations

To reinforce the repair of inguinal hernias, grafts of hernial sac, cutis, tantalum wire mesh or other foreign material may be necessary. *Patches are rarely necessary when the patient's own tissues are properly utilized in hernia repair.* When patches are deemed advisable, hernial sac grafts from the patient's own tissues are preferred. However, tantalum gauze has been reported as being satisfactory. Grafts, which are most frequently indicated in the male, should be carefully shaped and sutured in place so that they will not constrict the spermatic cord. It is probable that the incidence of infections is somewhat greater when grafts are used.

Technique of Cutis Graft (Fig. 549)

The skin of the donor site should be prepared carefully the day before and the day of operation. The size of the graft is estimated and outlined with glue on the drum of the Padgett dermatome (or other similar instrument). A hairless donor site should be selected. The epidermis is raised and left attached as a flap at one end as recommended by Swenson and Harkins. The cutis graft is then cut with the dermatome. The defect is covered with the epidermis flap. The graft is sutured under some tension over the required repaired transversalis fascia to the internal oblique muscle rectus sheath and inguinal ligament. In the Cooper's ligament repair it may be sutured to Cooper's ligament. It should be notched and sutured securely about the cord to the internal oblique muscle and inguinal ligament. The cord must not be constricted. The external oblique aponeurosis is sutured over the cord. The cutis graft has been used successfully for other types of hernia.

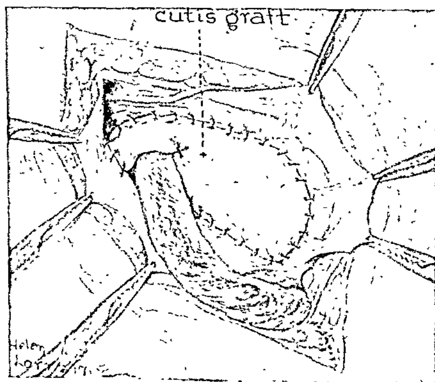


FIGURE 549 Illustrating the use of cutis graft in herniorrhaphy. (Shackelford: Surgery of the Alimentary Tract, Vol. III.)

Technique of Hernial Sac Graft

A section of hernial sac may be used as a patch in the repair of inguinal hernia. The thickened sac of a large and long-existing hernia is most desirable. The patch graft is sutured in place as are other patch grafts.

Technique of Tantalum Mesh Patch (Fig. 550)

A patch of tantalum mesh may be used to reinforce the repair of an inguinal hernia. After suture of the transversalis fascia the patch is sutured to the internal oblique muscle and rectus fascia over the pubic bone and to the inguinal ligament

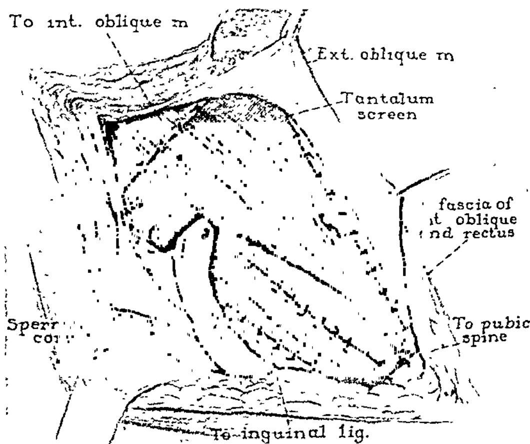


FIGURE 550. Technique of insertion of tantalum mesh to reinforce a hernia repair. (T. D. Throckmorton: Surgery, Vol. 23)

both medially and laterally to the cord. If a Cooper's ligament repair is used, the patch may be sutured to Cooper's ligament. The patch is notched to fit around the cord without constriction. Tantalum wire is the suture material of choice. (Note: it is the belief of the authors of this book that the use of tantalum mesh in the repair of inguinal hernias is rarely required.)

SLIDING HERNIA

General Considerations

This type of hernia involves the cecum on the right or the sigmoid on the left. There may be some difficulty in recognizing a sliding hernia at operation. If the con-

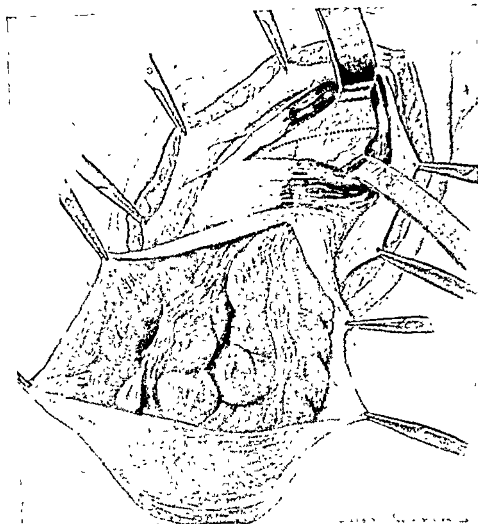


FIGURE 551. Technique of repair of sliding hernia through the abdominal approach. The sac is open, showing a sliding hernia of the sigmoid. An incision has been made through the internal oblique and transversalis muscles, exposing the peritoneum. (Williams· Ann Surg., Vol. 126, J. B. Lippincott Company)

dition is not recognized, serious injury to the bowel wall or its blood supply may result by attempts to free the hernial sac. Recurrences are not uncommon after repair of sliding hernias.

Technique of Repair (Williams)

An inguinal incision is made somewhat longer than the average. The external oblique aponeurosis is opened into the external ring, and the sac is exposed and dissected from the cord. The sac is opened through its anterior surface, and the sliding cecum or sigmoid is exposed. An opening is made into the abdomen through the internal oblique and transversus abdominis muscles about 3 cm. above the internal ring. The iliohypogastric nerve is avoided. A transverse opening is made in the peritoneum which exposes the contents of the hernial sac from above. The hernial sac and colon are completely mobilized and drawn upward through the abdominal incision. The excess peritoneum forming the sac is cut away, and the margins of the peritoneum are closed to restore the peritoneal covering of the colon mesentery. The sigmoid (or cecum) is then returned to the abdomen. The peritoneum, transversalis fascia and

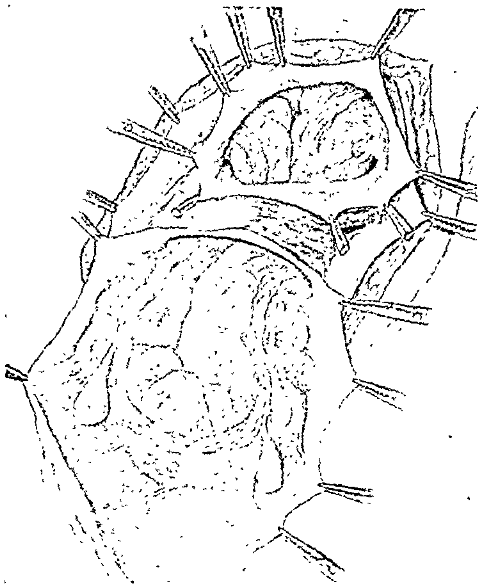


FIGURE 552. Technique of repair of sliding hernia through the abdominal approach (*continued*). The peritoneum has been opened, showing the sigmoid passing through the internal ring. (*Williams:* Ann. Surg, Vol. 126, J B Lippincott Company)

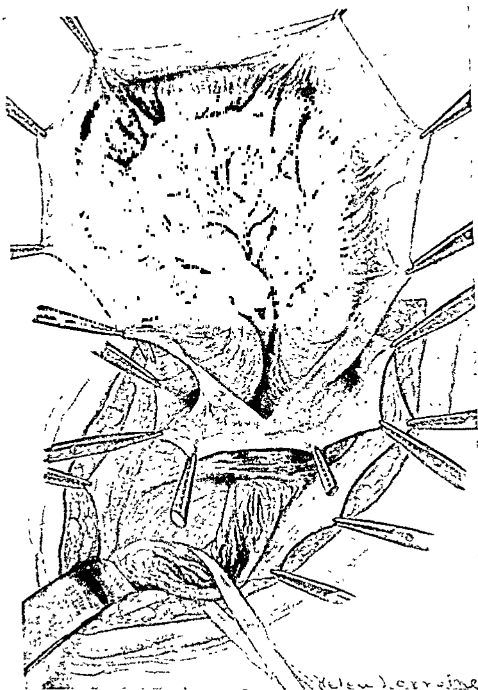


FIGURE 553. Technique of repair of sliding hernia through the abdominal approach (*continued*). The hernial sac has been trimmed, and the sigmoid has been withdrawn through the abdominal wound (Williams: Ann. Surg, Vol 126, J. B. Lippincott Company.)

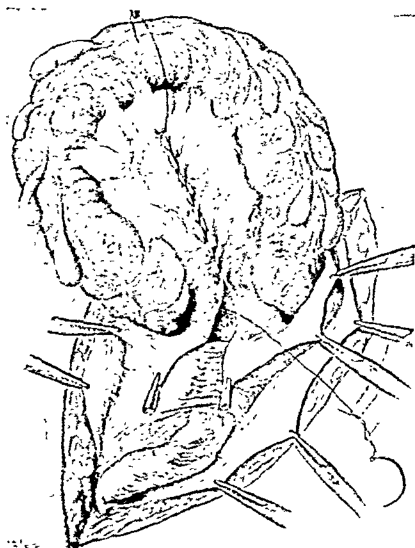


FIGURE 554. Technique of repair of sliding hernia through the abdominal approach (*continued*). The margins of the peritoneal sac have been sutured to reconstruct the outer leaf of the mesosigmoid. (Williams: Ann. Surg., Vol. 126, J. B. Lippincott Company.)

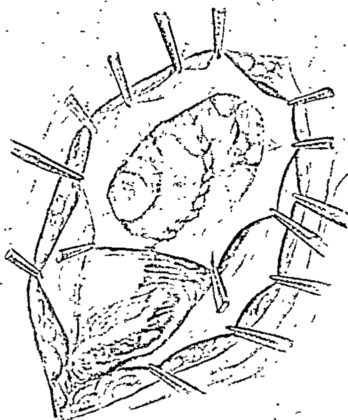


FIGURE 555 Technique of repair of sliding hernia through the abdominal approach (*continued*). The colon has been restored to the abdominal cavity. Note that the suture line in the mesocolon extends into the abdominal incision (Williams· Ann. Surg., Vol 126, J. B. Lippincott Company.)

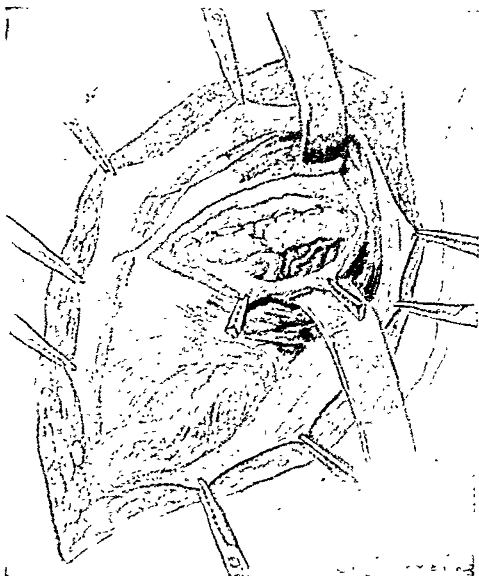


FIGURE 556 Technique of repair of sliding hernia through the abdominal approach (*concluded*). The peritoneum has been closed, and the margins of the transversalis fascia are shown. (Williams: Ann Surg, Vol 126, J B Lippincott Company.)

muscle, and the internal oblique are then closed in layers. The inguinal canal is then repaired by whatever method appears most appropriate to the surgeon. It is particularly important to close the internal ring securely about the cord.

Technique of Repair (Bevan) (Figs. 557, 558)

This technique may be used for sliding hernia of either the cecum or sigmoid. The hernial sac is exposed as in any type of large indirect inguinal hernia. To avoid injury to the blood supply of the bowel, the sac is opened cautiously, usually near the neck on the anteromedial side. The opening of the sac is enlarged to expose its contents. If on the right, the cecum and appendix are exposed, and the appendix should be removed. The sac is incised about that portion involved in the bowel wall about 2 cm. from the bowel. The bowel is lifted up and dissected free up to the neck of the sac. This step is done with great care to avoid injury to the blood supply to the bowel. The edges of the incised sac are sutured behind the bowel, and the defect left in the sac is repaired. The bowel is replaced in the abdominal cavity. The sac is closed at its neck with a purse-string suture placed from the inside of the sac. At this point the redundant portion of the sac may be excised or closed and inverted with a series of

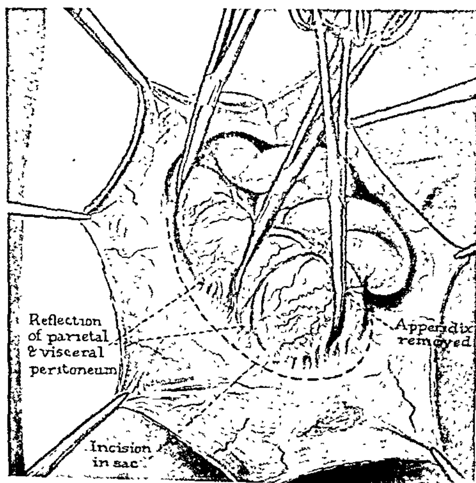


FIGURE 557. Technique of repair of sliding hernia of the large bowel (cecum). The appendix has been removed. The line of incision to be made in the sac about 2 cm. from the bowel wall is shown. This incision should extend to the neck of the sac on each side of the bowel. (R. R. Graham and M. B. Graham, Ann. Surg., Vol. 102.)

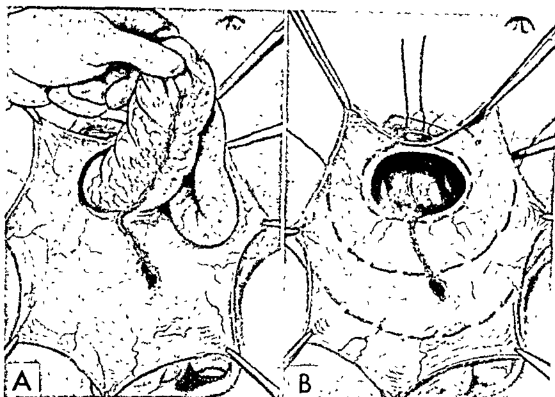


FIGURE 558 Technique of repair of sliding hernia of the large bowel (cecum) (*concluded*). *A*, A portion of the bowel forming a part of the sac wall has been lifted and peritonealized. The defect left in the hernia sac by this maneuver has been closed. *B*, The herniated bowel has been reduced into the abdomen, and 3 purse-string sutures have been placed for invaginating the sac. At this point the neck of the sac may be closed with a purse-string or continuous suture, or the sac may be closed and invaginated in steps with the already placed purse-string suture. (R. R. Graham and M. B Graham. Ann. Surg , Vol. 102.)

purse-string sutures as advised by Bevan. The hernial defect may then be repaired in a manner which appears most appropriate to the surgeon.

HERNIA OPERATION USING COOPER'S LIGAMENT

General Considerations

After a careful study of the anatomy of the inguinal region McVay and Anson concluded that the transversalis fascia, the transversus abdominis aponeurosis and the internal oblique aponeurosis are not normally inserted into the inguinal (Poupart's) ligament, and, from the surgical viewpoint, the inguinal ligament is not suitable for insertion of the structures because of its character. For the repair of large indirect and direct inguinal hernias these authors recommend that the inguinal layers be sutured to Cooper's (ligamentum pubicum superius) ligament.

Essentially the same technique may be used for all types of inguinal and femoral hernias.

Technique of Herniorrhaphy Using Cooper's Ligament (Figs. 559 to 562)

The hernia is exposed as in other oper r inguinal her 560). The cord is mobilized from the floor of the in l by both blu rp dissection, some care being taken to separate a f the crema from the

transversalis fascia. The cord is then entered and the indirect sac identified, dissected free from the cord and opened. Through the indirect hernial sac careful exploration is made for evidence of a direct or femoral hernia. If either is found, the sac is freed by blunt dissection and traction and drawn beneath the interior epigastric vessels (Hoguet maneuver) to become a part of the indirect sac. The neck of the sac is closed by transfixion ligature or suture, after which the redundant sac is excised. The cremaster muscle and fascia are then removed from the cord, all bleeding points being clamped and ligated carefully with fine suture material. The attenuated transversalis fascia is then incised, exposing the properitoneal fat (Fig. 561). Through this tissue Cooper's ligament may easily be exposed by blunt dissection. Care must be taken not to injure either the inferior epigastric vessels or the frequently encountered aberrant obturator vessels which cross Cooper's ligament. The transversalis fascia is then sutured to Cooper's ligament with interrupted sutures sufficiently strong to allow secure repair (Fig. 561). The femoral vessels must be protected by lateral retraction. The most lateral stitch through Cooper's ligament is usually about 4 cm. from the pubic spine. A half-curved Davis tonsil needle is recommended for use in this stage in the procedure.

The placing of this row of sutures will be facilitated by passing the needle first through Cooper's ligament with the point of the needle directed away from the surgeon. The suture line is then carried laterally, approximating the edge of the transversalis fascia to the femoral sheath which reconstructs the internal inguinal ring (Fig. 562). The cord is allowed to drop back into its position in the inguinal canal, and the external oblique, superficial fascias and skin are closed in layers.

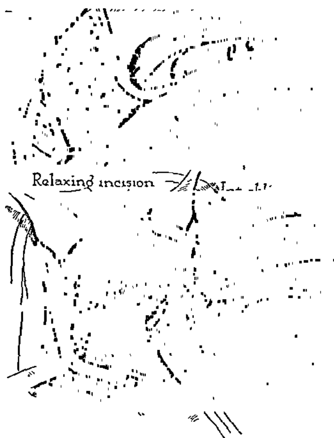


FIGURE 559. Posterior view of the anatomy of large right indirect hernia. (C. B McVay: Hernia Springfield, Ill, Charles C Thomas)

FIGURE 560. Anterior view of large right inguinal hernia. (C. B McVay. Hernia. Springfield, Ill., Charles C Thomas.)

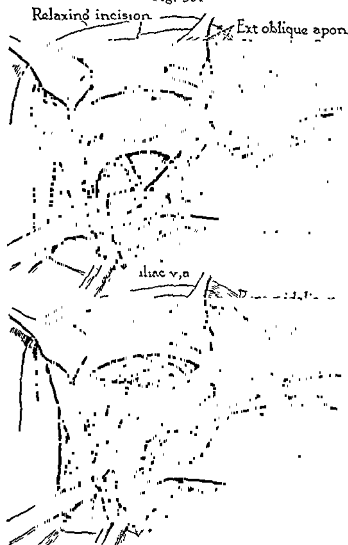


FIGURE 561. The relaxing incision has been made, attenuated transversalis fascia excised, and the sac ligated and excised. (C. B McVay: Hernia. Springfield, Ill., Charles C Thomas.)

FIGURE 562. The transversalis fascia has been sutured medially to Cooper's ligament and laterally to the femoral sheath, completing the repair of the floor of the inguinal canal (C. B. McVay: Hernia. Springfield, Ill., Charles C Thomas.)

OPERATIONS FOR DIRECT INGUINAL HERNIA

Anatomy

The sac of a direct inguinal hernia protrudes directly through the abdominal wall medial to the deep epigastric vessels which outline the lateral portion of Hesselbach's triangle. In this triangle, which is formed by the lateral margin of the rectus muscle, Poupart's ligament and the deep epigastric vessels, are the medial portion of the internal oblique muscle, the conjoined tendon, transversalis fascia and areolar tissues. A direct hernial sac is covered with a layer of properitoneal fat, areolar tissue and transversalis fascia. There may also be present an indirect sac which, when exposed with the direct sac, forms a double or "pantaloon" type of hernia. If a "pantaloon" hernia exists, it may be repaired as an indirect hernia by withdrawing the direct sac laterally from beneath the deep epigastric vessels, converting the two sacs into one.

Technique of Operation for Direct Inguinal Hernia (McVay) (Figs. 563 to 566)

The inguinal canal is exposed as in the Bassini operation (Fig. 564). The remainder of the procedure is carried out in almost identical fashion previously de-

Fig. 563.

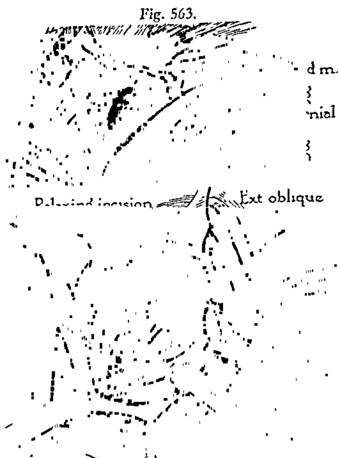


FIGURE 563. Posterior view of anatomy of a right direct inguinal hernia. (C. B. McVay: Hernia. Springfield, Ill., Charles C Thomas.)

FIGURE 564. Anterior view of right inguinal region with direct hernia (C. B. McVay: Hernia. Springfield, Ill, Charles C Thomas.)

Fig. 564.

Fig 565.

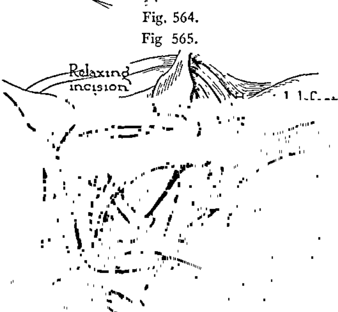


FIGURE 565. Attenuated transversalis fascia has been excised and a relaxing incision *made in the rectus sheath* (C. B McVay: Hernia. Springfield, Ill, Charles C Thomas)



FIGURE 566 Reconstruction of the floor of the inguinal canal completed by suturing the edge of the transversalis fascia to Cooper's ligament and the femoral sheath. (C B McVay: Hernia. Springfield, Ill, Charles C Thomas)

Fig. 566.

scribed under McVay's technique of repair of indirect inguinal hernia. However, the *excision of the attenuated transversalis fascia* (Fig. 565) *is carried completely to the* pubic spine. The remainder of the repair is accomplished in an identical manner.

Technique of Operation for Direct Inguinal Hernia (Farris) (Figs. 567 to 570)

The Farris technique is particularly appropriate in those cases in which the transversalis fascia is of such poor quality that its use in a Cooper's ligament repair is deemed inadvisable.

The aponeurosis of the external oblique fascia is exposed and its fibers divided longitudinally. The spermatic cord is again dissected free from its position in the floor of the inguinal canal. The cord is explored for an indirect sac. If a sac is found, it is handled in a manner similar to that previously described. An incision is then made in the transversalis fascia exposing the properitoneal fat (Fig. 567). Cooper's ligament is then exposed by blunt dissection, care being taken to avoid injury to aberrant obturator vessels or the inferior epigastric vessels. An incision is then made into the exposed Cooper's ligament (Fig. 568). After separation of the fascia of the external oblique medially as far as possible, a triangular flap of rectus fascia is constructed (Fig. 569). This flap is reflected laterally and inferiorly and sutured with interrupted sutures to Cooper's ligament. Laterally the suture line is continued, approximating this flap to the femoral sheath as previously described by McVay (Fig. 570). The

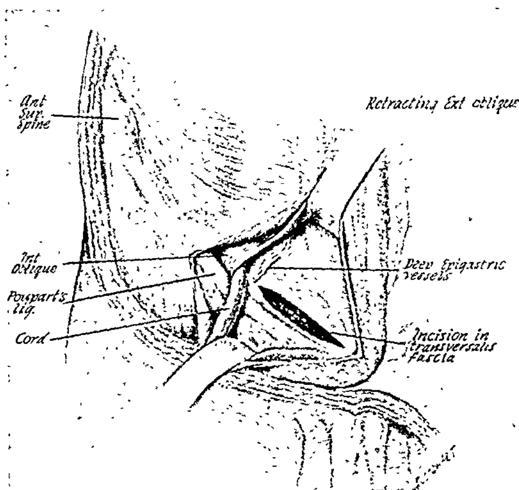


FIGURE 567. Incision of transversalis fascia to expose Cooper's ligament. (J. M. Farris, J. Ettinger and J. A. Weinberg. Surgery, Vol. 24.)

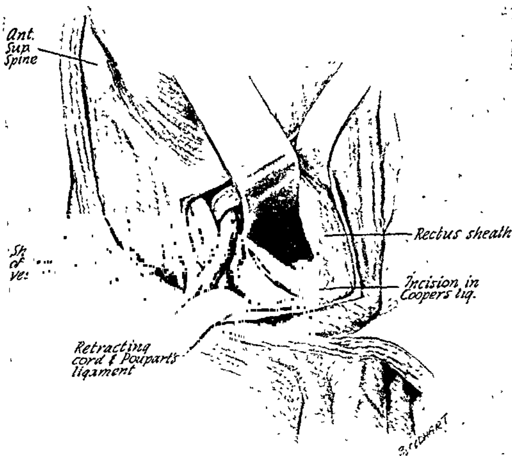


FIGURE 568. An incision is made in the exposed Cooper's ligament, extending over the pectineus fascia to the femoral sheath. (J. M Farris, J. Ettinger and J. A. Weinberg: Surgery, Vol. 24.)

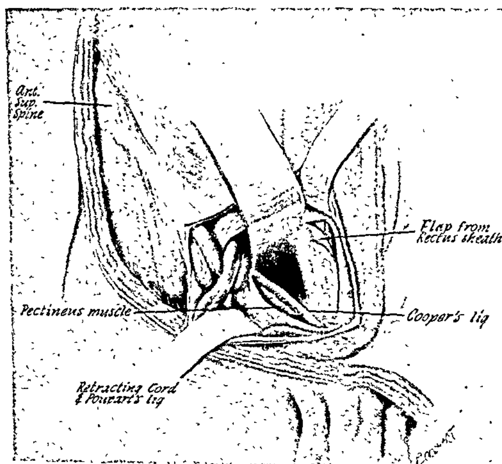


FIGURE 569. Construction of the triangular flap of rectus fascia. (J. M. Farris, J. Ettinger and J. A. Weinberg: Surgery, Vol 24.)

scribed under McVay's technique of repair of indirect inguinal hernia. However, the excision of the attenuated transversalis fascia (Fig. 565) is carried completely to the pubic spine. The remainder of the repair is accomplished in an identical manner.

Technique of Operation for Direct Inguinal Hernia (Farris) (Figs. 567 to 570)

The Farris technique is particularly appropriate in those cases in which the transversalis fascia is of such poor quality that its use in a Cooper's ligament repair is deemed inadvisable.

The aponeurosis of the external oblique fascia is exposed and its fibers divided longitudinally. The spermatic cord is again dissected free from its position in the floor of the inguinal canal. The cord is explored for an indirect sac. If a sac is found, it is handled in a manner similar to that previously described. An incision is then made in the transversalis fascia exposing the properitoneal fat (Fig. 567). Cooper's ligament is then exposed by blunt dissection, care being taken to avoid injury to aberrant obturator vessels or the inferior epigastric vessels. An incision is then made into the exposed Cooper's ligament (Fig. 568). After separation of the fascia of the external oblique medially as far as possible, a triangular flap of rectus fascia is constructed (Fig. 569). This flap is reflected laterally and inferiorly and sutured with interrupted sutures to Cooper's ligament. Laterally the suture line is continued, approximating this flap to the femoral sheath as previously described by McVay (Fig. 570). The

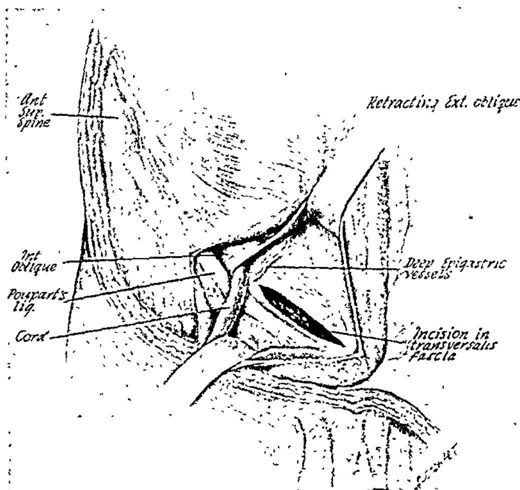


FIGURE 567. Incision of transversalis fascia to expose Cooper's ligament. (J M Farris, J. Ettinger and J. A Weinberg Surgery, Vol. 24.)

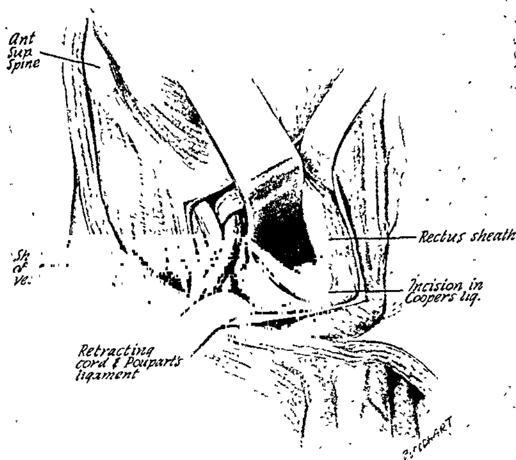


FIGURE 568. An incision is made in the exposed Cooper's ligament, extending over the pectineus fascia to the femoral sheath. (J. M. Farris, J. Ettinger and J. A. Weinberg: Surgery, Vol. 24.)

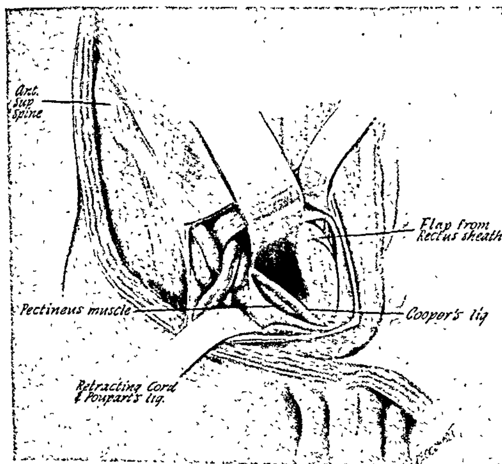


FIGURE 569. Construction of the triangular flap of rectus fascia. (J. M. Farris, J. Ettinger and J. A. Weinberg: Surgery, Vol. 24)

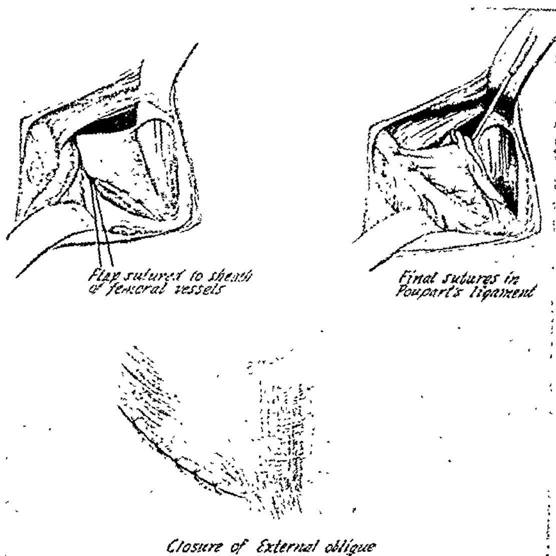


FIGURE 570 The rectus flap is turned down and sutured to Cooper's ligament The line of suture extends up over the femoral sheath to Poupart's ligament, and interposes an extra layer of fascia into the pyramidal defect constituting the direct hernia. There is no tension on suture lines (J. M. Farris, J Ettinger and J A Weinberg: Surgery, Vol 24)

remainder of the hernia repair is accomplished by approximating the external oblique anterior to the cord with interrupted sutures. This technique has the advantage in common with that originally described by McVay of being appropriate for the repair of not only indirect but also direct inguinal and femoral hernias. It has another advantage in that the repair is made with a minimum of tension upon suture lines.

STRANGULATED INGUINAL HERNIA

Technique of Operation

The hernial sac should be exposed as in the reducible type of hernia. The sac is then carefully opened, avoiding injury to its contents. Dissection is made down to the constriction so that it may be divided under direct vision. Exposure is aided by traction on the sac wall. The constriction should be divided upward and outward. In the direct hernia there is danger of wounding the bladder by a medial incision. There is also some danger of severing the deep epigastric vessels with a lateral incision. If the deep epigastric vessels are cut, they must be clamped and ligated.

After the constriction has been released the condition of the strangulated loop of intestine must be carefully observed before the intestine is reduced into the abdomen. If the peritoneal covering retains its luster, the intestine may be considered viable. The application of warm saline sponges will tend to restore the normal color. If the bowel is gangrenous, resection and anastomosis are indicated. In the more serious cases it is sometimes preferable to leave the gangrenous bowel exteriorized in the wound and drain, postponing the anastomosis until later. Rarely it may be necessary to open the abdomen to resect or exteriorize the damaged loop of intestine. After the sac contents have been reduced, the repair is completed as in an uncomplicated hernia.

OPERATION FOR FEMORAL HERNIA

Anatomy

A femoral hernia passes out through the femoral ring and femoral canal. The femoral ring is bounded in front by Poupart's ligament, behind by the iliopectineal line of the os pubis, origin of the pectineus muscle, pubic portion of the fascia lata and Cooper's ligament, medially by Gimbernat's ligament, and laterally by the femoral vein. It is an oval opening varying in diameter from 1.25 to 2.5 cm. It is larger in women than in men. It is normally closed by areolar tissue called the septum crurale.

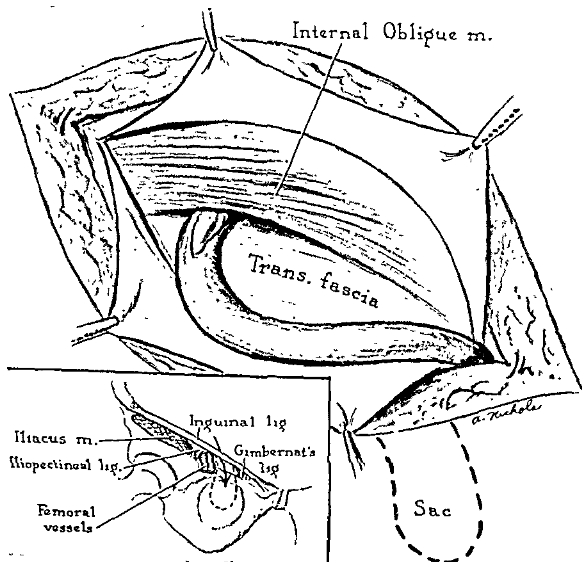


FIGURE 571. Showing anatomical relationship in femoral hernia.

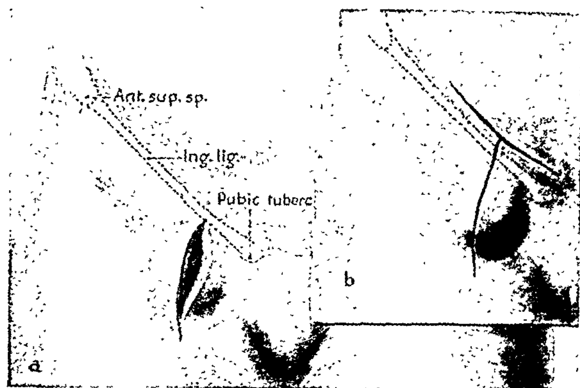


FIGURE 572. Femoral hernia with gangrenous bowel. Skin incision (*a*) permits recognition of gangrenous bowel without opening sac. Incision (*b*) is made if gangrene is found. (Dennis and Varco: Surgery, Vol. 22.)

The femoral canal is below the femoral ring just medial to the femoral vein. It is about 0.7 to 1.25 cm. in length and extends from Gimbernat's ligament downward to the upper part of the saphenous opening. It is normally filled with fatty tissue and lymphatics. A loose sheath of fascia surrounds the femoral canal. The femoral artery is lateral to the femoral vein.

The saphenous opening in the fascia lata below Poupart's ligament through which a femoral hernia protrudes measures about 1.5 by 2.25 cm. in diameter. Through this opening passes the saphenous vein to join the femoral vein. The falciform process is a curved portion of the fascia lata forming the upper and lateral margins of the saphenous opening. Over the aperture is the cribriform fascia. The coverings of a femoral hernia from within outward are the peritoneum, properitoneal fat, septum crurale, femoral sheath, cribriform fascia, superficial fascia and skin.

Dangers and Safeguards

The two most important structures that may be injured in femoral hernia repair are the femoral vein and the bladder. If the hernia is strangulated, an intestinal loop may be injured. These dangers may be avoided by carefully dissecting away all fat and areolar tissue about the sac before an attempt is made to ligate the neck of the sac or place the closing sutures. A few minutes spent in clearing the field and identifying anatomical structures will aid in the prevention of operative errors.

Technique of Operation for Femoral Hernia (Higgins) (Fig. 571)

Incision is made in the skin and external oblique aponeurosis as in inguinal herniorrhaphy. In the male the spermatic cord is mobilized and dissected downward. After separating the fibers of the cremaster muscle, a small peritoneal diverticulum (or hernial sac) lying on the anteromedial aspec. of the cord is identified and grasped

with forceps. This small indirect sac or diverticulum can nearly always be found even in normal persons. The sac is opened, and the index finger is inserted to examine the femoral canal and the floor of Hesselbach's triangle from within. By exerting gentle traction on the medial portion of the peritoneum it is possible to deliver the entire femoral sac through the internal inguinal ring and lateral to the inferior epigastric vessels (Hoguet maneuver). Even large sacs can be mobilized with ease in this manner after their contents have been reduced. The sac is then freed of properitoneal fat by blunt and sharp dissection, taking care not to injure the bladder or inferior epigastric vessels. The peritoneal sac can then be closed by either a purse-string suture or transfixion ligature and the redundant portion excised. The transversalis fascia, which is usually strong in cases of femoral hernia, is opened along the shelving border of the inguinal ligament, affording good exposure to the femoral canal and Cooper's ligament.

In rare instances when difficulty is encountered in reducing the hernial contents or mobilizing the sac, pressure may be exerted from below the inguinal ligament combined with gentle traction from above. The fibers of the lacunar ligament which constitutes the medial wall of the femoral canal may be divided under direct vision to enlarge the canal.

The femoral canal is then closed by placing a short row of interrupted sutures between the medial shelving portions of the inguinal ligament and pectineal fascia which makes up the floor of the canal. The principal part of the repair is then carried

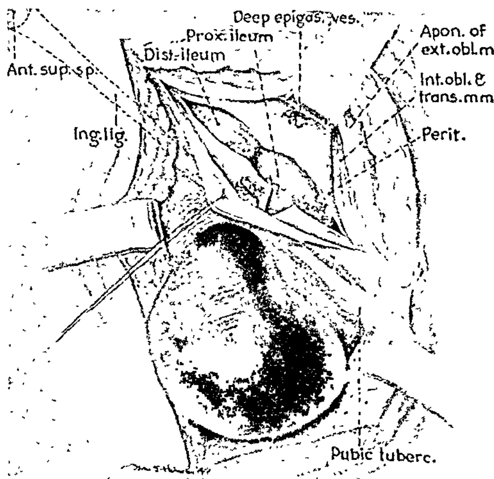


FIGURE 573. Femoral hernia with gangrenous bowel (*continued*). Incision has been made through the abdominal wall, and the hernial sac has been exposed. (Dennis and Varco: Surgery, Vol. 22.)

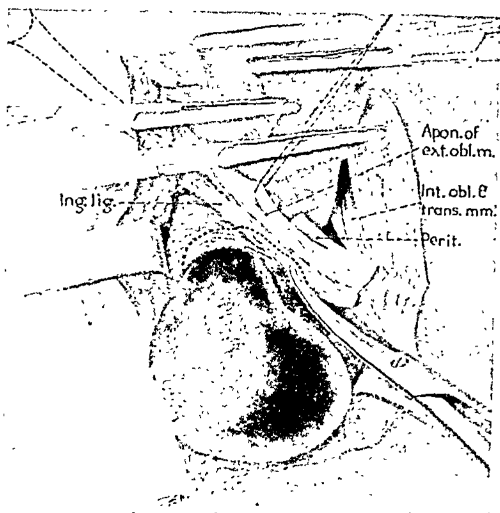


FIGURE 574 Femoral hernia with gangrenous bowel (*continued*) The proximal and distal segments of the bowel have been divided. The inguinal ligament has been divided, and a fibrous ring about the neck of the sac is outlined (Dennis and Varco, Surgery, Vol 22.)

out by approximating the medial cut edge of the transversalis fascia to Cooper's ligament after the method of McVay. It is important to continue the suture line laterally, approximating the transversalis fascia to the femoral sheath anterior to the vessels providing a snug closure to the internal ring. A rectus-fascia relaxing incision may be made if deemed necessary. The spermatic cord is replaced in its bed and the external oblique aponeurosis, subcutaneous tissue and skin closed as in inguinal herniorrhaphy.

Technique of Operation for Femoral Hernia with Gangrenous Bowel (Dennis and Varco)

The patient is prepared for operation as for other types of small bowel obstruction. The time of preparation should not exceed three or four hours. A catheter placed in the bladder is advised. Local, spinal or inhalation anesthesia may be used, depending upon the condition of the patient.

A vertical incision is made over the swelling in the groin (Fig. 572, *a*). If gangrene is detected through the hernial sac, a second incision is made 2 cm. above the inguinal ligament and connected with the vertical incision to make a *T*-shaped incision (Fig. 572, *b*). The aponeurosis of the external oblique is split 1 cm. above the

inguinal ligament and extended into the external ring. The incision is extended through the aponeurosis of the transversus muscle and peritoneum. The cord (in the male) is elevated, and the inferior epigastric vessels are divided and ligated. Dissection through the vertical incision will isolate the hernial sac with its contents (Fig. 573).

The bowel above the hernial opening is freed, and the mesentery of the involved segment is ligated and divided. The bowel proximal and distal to the hernia is divided between Ochsner clamps. The inguinal ligament is divided near its attachment to

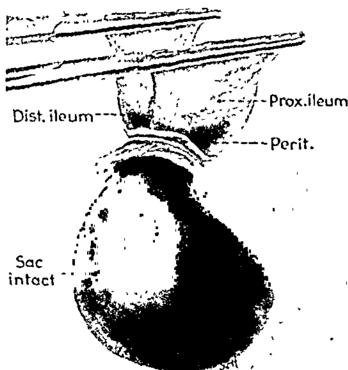


FIGURE 575. Femoral hernia with gangrenous bowel (*continued*) Hernia with intact sac has been removed. (Dennis and Varco: Surgery, Vol. 22.)

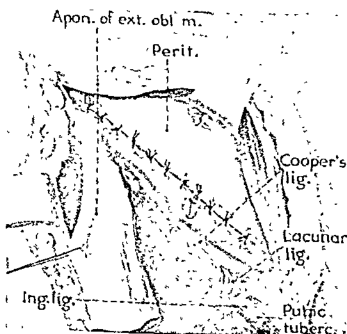


FIGURE 576. Femoral hernia with gangrenous bowel (*continued*) The peritoneum has been closed with interrupted sutures of silk. (Dennis and Varco. Surgery, Vol. 22.)

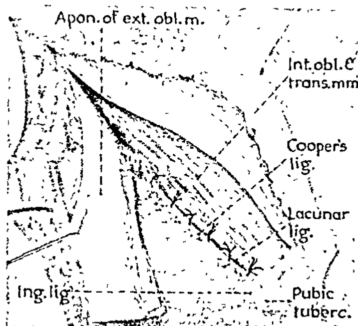


FIGURE 577. Femoral hernia with gangrenous bowel (*continued*). The transversalis fascia and internal oblique muscle have been sutured to Cooper's ligament with interrupted silk sutures from the pubic bone to the femoral vessels (Dennis and Varco· Surgery, Vol. 22.)

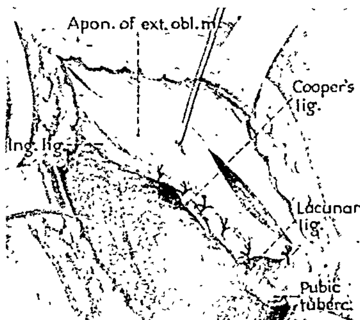


FIGURE 578 Femoral hernia with gangrenous bowel (*continued*) The inguinal ligament has been reconstructed by suturing its medial end to the lacunar ligament and its margin to Cooper's ligament. (Dennis and Varco. Surgery, Vol 22)

the pubes and split laterally. The dissection is continued around the neck of the sac, leaving a fibrous ring (Fig. 574). The hernial sac and segment of bowel may now be removed intact without soiling the operative field (Fig. 575.) An end-to-end anastomosis of the bowel is made.

¶ The hernial and surgical defects are repaired by using the Cooper's ligament technique. The peritoneum is closed with interrupted sutures (Fig. 576). The margins of the internal oblique and transversus muscles and conjoined tendon are sutured to Cooper's ligament from the pubic bone to the femoral vessels. A relaxing incision in the anterior rectus sheath may be used if necessary to relieve tension.

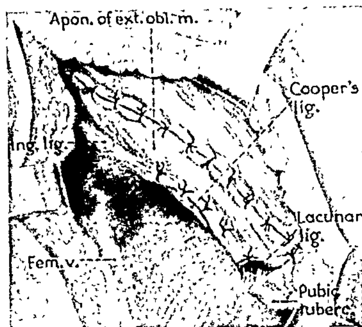


FIGURE 579. Femoral hernia with gangrenous bowel (*concluded*) The aponeurosis of the external oblique has been closed down to the pubic bone (female) (Dennis and Varco: Surgery, Vol. 22.)

The inguinal ligament is reconstructed by suturing its severed end to the lacunar ligament and the margin to Cooper's ligament (Fig. 578). Closure of the external oblique aponeurosis (over the cord in the male) completes the repair.

Interrupted silk sutures are used throughout the operation. If there is evidence of necrosis of the bowel, it is enclosed in a moist pack during the dissection to prevent contamination of the operative field.

OPERATIONS FOR UMBILICAL HERNIA

Technique of Operation (Mayo) (Fig. 580)

A transverse elliptical incision is made around the protruding mass. The fat is incised, exposing the fascia of the rectus muscles. All fat is removed from the neck of the sac outward in all directions for a distance of about 4 to 5 cm. to expose the fascia. The junction of the sac neck and the fascia is identified, and the sac is incised near the neck. The contents of the sac are carefully inspected, and adhesions are divided. If a mass of omentum is contained in the sac, it may be ligated in small sections with multiple ligatures and removed. If the sac contains strangulated bowel, it must be treated as other strangulated hernias. If there is difficulty in reducing the hernia, the constricting fascia may be divided laterally in one or both directions. After the hernial content has been reduced the sac is removed at the neck and closed when possible.

The peritoneum may be freed and sutured as a separate layer, but this is not essential. Lateral incisions are made into the rectus sheaths, making the hernial opening elliptical in shape. The lower fascial flap is then sutured beneath the upper flap (or vice versa), with interrupted mattress sutures overlapping the flaps about 3 to 4 cm. The sutures are all placed before any is tied. The upper flap is sutured to the lower with mattress or interrupted sutures, using care not to enter the peritoneum

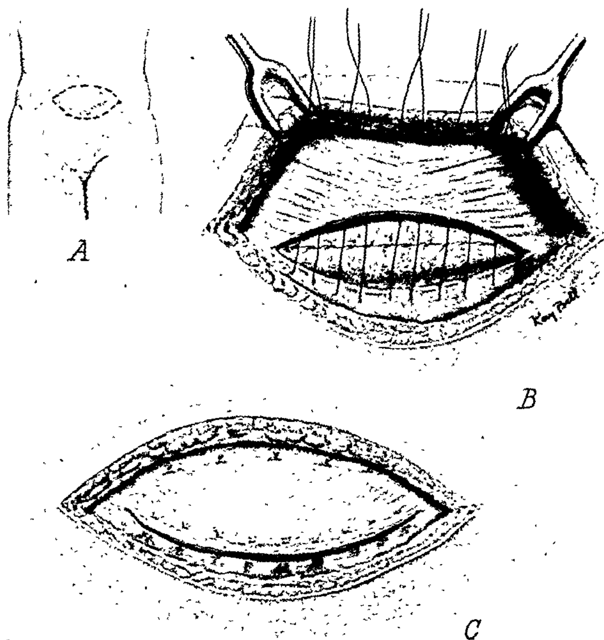


FIGURE 580 Mayo technique for repair of umbilical hernia *A*, Lines of incision. *B*, Peritoneum has been closed with a continuous suture. Mattress sutures placed to imbricate fascia. *C*, Repair completed

with the needle The subcutaneous tissue is approximated with sutures, and the skin is closed as in any abdominal incision.

Technique of Operation for Infantile Umbilical Hernia

A large majority of umbilical hernias in infants can be cured in a few months by nonoperative, mechanical methods of treatment. Operation is indicated when the hernia is large or when there are recurrent symptoms of incarceration or strangulation.

When operating upon an infantile umbilical hernia, it is usually possible and advisable to preserve the umbilicus. A curved incision is made below the umbilicus, and the skin and fascia flap, including the umbilicus, is turned upward (Fig. 581) The sac is freed about the neck, exposing the umbilical ring. The contents of the sac

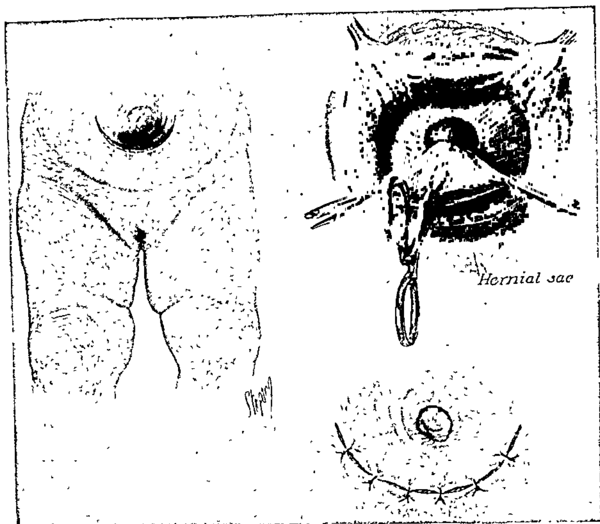


FIGURE 581. Technique of repair of an infantile hernia. A curved incision is made below the umbilicus A flap is turned up, preserving the umbilical dimple. The sac is freed, ligated and removed. The defect in the abdominal wall is closed by imbricating its margins similar to the Mayo technique for repair of umbilical hernia in the adult. (Watson· Hernia, C. V. Mosby Company.)

are reduced, and the sac is transfixed and ligated or excised and closed with sutures. The fascial margins are overlapped laterally or as in the Mayo operation. Mattress sutures of chromic catgut or fine silk are used. The skin is closed with interrupted sutures, and a pressure dressing is applied.

OPERATION FOR EPIGASTRIC HERNIA

Technique of Operation

This small hernia which occurs in the linea alba, usually above the umbilicus, is repaired by overlapping the fascial margins of the opening transversely or longitudinally. An incision 4 to 5 cm. is made over the hernia and the protruding fat reduced or excised. There is rarely a hernial sac. The margins of the opening are freed from fat and slightly enlarged laterally or parallel with the linea alba. The margins are then overlapped about 1 cm., using a double row of mattress sutures for closure.

Large hernias sometimes occur through the linea alba. These are usually closed by the technique used for the repair of umbilical hernia.

OPERATIONS FOR INCISIONAL HERNIA

General Considerations

The type of operation indicated in the repair of incisional or ventral hernia depends upon the size and location of the hernia. When possible, such hernias should be repaired with the patient's tissues. Small incisional hernias may be repaired by dissecting out the anatomical layers of the abdominal wall and closing them separately. Overlapping of the fascia or aponeurosis improves the repair in some cases.

Grafts of various types have been used in the repair of large hernias. These are fascial grafts, cutis grafts, full-thickness skin grafts, hernia sac grafts and grafts of tantalum mesh, Fiberglas or other foreign materials. Grafts of any type tend to increase the incidence of infection and recurrence. These complications may be expected, since the hernias requiring grafts are the large types and most difficult to repair. It is obvious, then, that incisional hernias should be repaired with scrupulous exactitude.

Occasionally incisional or umbilical hernias have grown so large that there is not sufficient room in the abdominal cavity to safely replace the sac contents; the hernial content has lost its right of domicile. In such instances the omentum and a segment of colon have been removed. Resection of the bowel increases the hazard of operation and predisposes to infection and should rarely be done. In rare instances a portion of the hernial sac and overlying skin may be excised to reduce the size of the hernia as much as safety will permit, followed by closure of the peritoneum and skin similar to the technique of repair of a large omphalocele (Fig. 585). Such a plan would require two or more operations done at intervals of several months. Koontz has recommended trial of a period of pneumoperitoneum to enlarge the abdominal capacity in those cases of hernia in which it appears questionable that the contents may be contained within the abdomen.

Dangers and Safeguards

It is obvious that the field of operation should be prepared carefully to avoid infection. Since many of the patients with incisional hernias are advanced in years, careful evaluation and general preparation of such patients are mandatory. The choice of anesthetic is important. Operation may be prolonged, making supportive treatment necessary during the operation.

Unexpected technical difficulties may be encountered. The size of the hernial opening cannot always be determined with accuracy before operation. The surgeon must be prepared to change his plan of procedure

Simple closure of an incisional hernial defect without overlapping is likely to be unsuccessful. Imbrication of the fascia or of the full thickness of the abdominal wall is desirable.

The recurrence rate following repair of incisional and ventral hernias is higher than that in inguinal hernias. When grafts are used in the repair, Koontz has emphasized the importance of placing the margins of the grafts well beyond the margins of the defect to prevent recurrence through weak areas. McVay has stated that even though repair of large incisional hernias is successful, through the months and years

weakness and bulging may develop at the site of the hernia. He advises constant protection of the hernial repair by the use of postoperative abdominal supports.

Technique of Repair of Incisional Hernia in Five Layers (Cattell)

Traction is applied to the scar with Allis clamps, and the scar, excess skin and the underlying hernial sac are excised (Fig. 585). The remaining hernial sac is dissected free of adhesions on the inside and separated from the skin and subcutaneous tissue beyond the hernial defect on the outside. All fat is carefully removed from the neck of the sac and adjacent surrounding abdominal wall fascia. It may be advisable to excise large portions of the omentum.

The first of the five layers to be sutured is the peritoneum. This closure is made from inside the sac, uniting the margins of the defect, including all layers of the

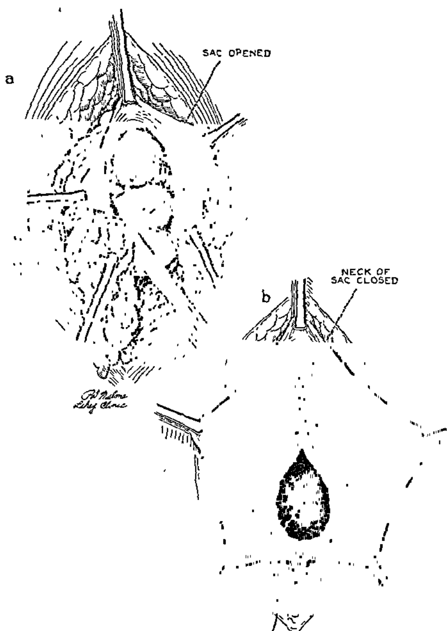


FIGURE 582. Technique of the 5-layer repair of incisional hernia. The sac has been opened and freed of its contents. The skin and fat have been dissected from the sac. The defect is being closed with a continuous lock-stitch suture of heavy chromic catgut which passes through the complete thickness of the abdominal wall. The dotted *line shows the line of incision* for removal of excess sac. (Cattell: Surgical Practice of the Lahey Clinic, 1951.)

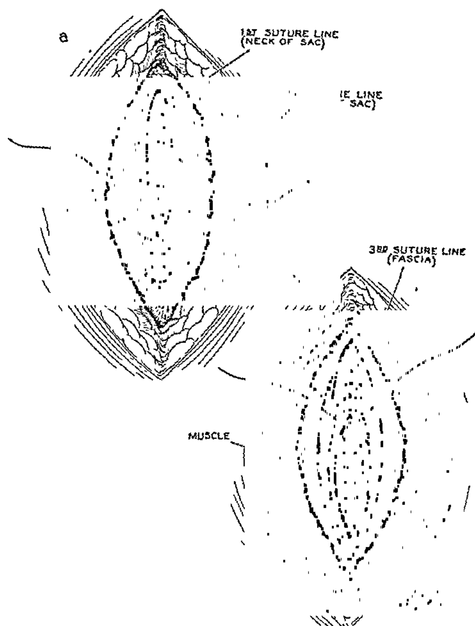


FIGURE 583 The remaining free edge of the hernial sac is being sutured. The dotted line indicates line of incision through the fascia (Cattell Surgical Practice of the Lahey Clinic)

abdominal wall. Although heavy chromic catgut has been advised for suture material by Cattell, many surgeons prefer interrupted sutures of silk or cotton.

The redundant hernial sac is cut away 2 cm. from the first suture line. The thickened margins of the hernial sac are closed over the primary suture line. If the abdominal defect is large, alloy steel wire may be used for the first two rows of sutures (Fig. 582).

An elliptical incision is made through the abdominal wall fascia 2 cm. lateral to the second suture line to expose the underlying muscle, as indicated by the dotted line in Figure 583. The muscle is freed as much as necessary, and the posterior fascial layer is united with interrupted sutures. The anterior fascia is separated from the muscle layer and approximated with interrupted sutures which alternate with the posterior fascial sutures (Fig. 584).

If the fascial closure is under too much tension, lateral relaxing incisions may be made in the fascia some distance from the suture line.

After the closure of the defect in five layers the subcutaneous tissues and skin are

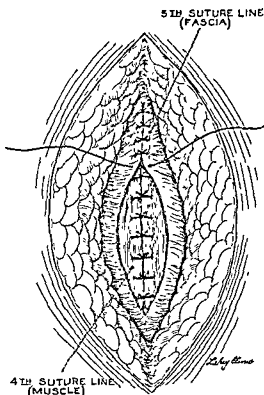


FIGURE 584. The anterior fascial layer is being closed with interrupted sutures which alternate with sutures in the posterior fascial layer. (Cattell: Surgical Practice of the Lahey Clinic)

closed in separate layers. If there has been much separation of the skin and subcutaneous tissues from the abdominal wall, drainage is indicated for forty-eight hours to prevent the accumulation of serum.

Technique of Repair Using Hernial Sac

When the defect in the abdominal wall is not too large, an incisional hernia may be satisfactorily repaired by utilizing flaps cut from the hernial sac and by overlapping the full thickness of the abdominal wall.

The scar and redundant skin over the hernia are excised (Fig. 585). The hernial sac is dissected free of adhesions within and of fat without. The abdominal wall is freed of fat around the border of the defect a distance of about 4 cm. A flap of hernial sac 2 cm. wide is shaped on each side of the defect.

An estimate is made of the extent to which the full thickness of the margins of the abdominal wall may be overlapped. They should be overlapped at least 2 cm. One margin of the defect is raised, and the hernial sac flap from the opposite margin is sutured under slight tension to the under surface of the abdominal wall about 4 cm. from the margin of the defect with interrupted sutures. These sutures should be passed deep through the peritoneum to penetrate the underlying deep fascia or sutured directly to the fascia through an incision in the peritoneum. The full thickness of the abdominal wall is then overlapped and sutured with two rows of interrupted sutures. The other peritoneal flap is sutured to the anterior abdominal wall fascia about 2 cm. beyond the margin of the last suture line to complete the closure of the defect. No. 000 silk or cotton is used as suture material.

The subcutaneous tissues and skin are closed with no. 0000 silk or cotton. A rubber tissue drain may be used for twenty-four to forty-eight hours to prevent the accumulation of serosanguineous exudate. A pressure dressing is used.

Technique of Repair Using Hernial Sac and Tantalum Gauze

The scar and redundant skin over the hernia are suspended and held under tension while being excised (Fig. 585). Adhesions are freed from the inside of the sac, and all fat is dissected from the outside of the sac to a line on the abdominal wall fascia 4 cm. from the margin of the abdominal wall defect.

The margins of the hernial sac are shaped to form flaps wide enough to cover the defect plus a margin 3 cm. wide for overlapping. One flap is sutured to and beneath the opposite abdominal wall defect at least 1 cm. from the defect margin. These sutures should pass through the peritoneum to grasp the fascia, or an incision should

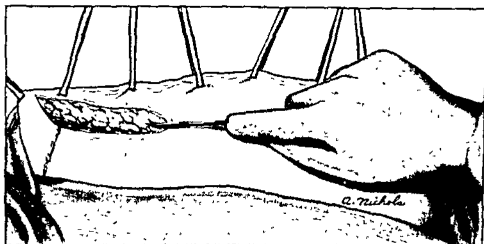


FIGURE 585. Excision of redundant skin and scar over incisional hernia

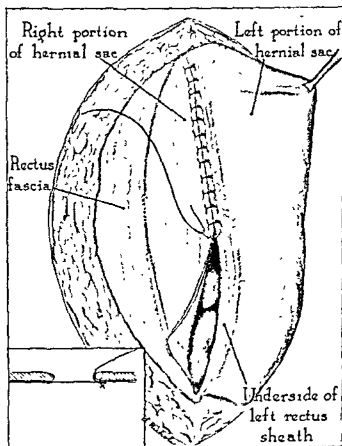


FIGURE 586 Right leaf of hernial sac sutured to under edge of left rectus sheath.

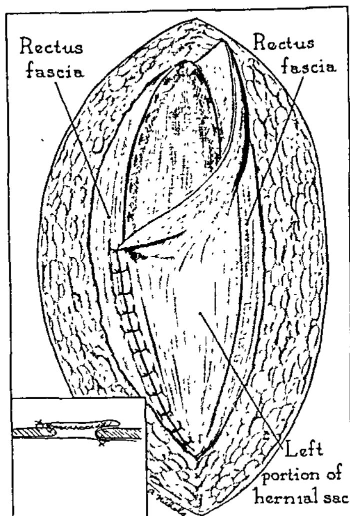


FIGURE 587. Tantalum gauze patch is in place, and left leaf of hernial sac is being overlapped and sutured to the right rectus muscle.

be made in the peritoneum to permit suture of the hernia sac flap direct to the fascia (Fig. 586). Suturing the first flap of sac closes the opening in the abdominal wall. A patch of tantalum mesh is shaped to fit the abdominal wall defect and sutured to the abdominal wall 1 cm from the defect margins. The margins of the patch are folded either anteriorly or posteriorly and sutured with mattress sutures of tantalum wire passed through the folded margins of the patch (Fig. 587). The patch should fit snugly, but should not be placed under tension. The anterior flap of hernial sac is sutured over the tantalum patch to the abdominal wall fascia 1 cm. beyond the margin of the patch

The subcutaneous fat and fascia and skin are closed with interrupted sutures of no 000 silk or cotton. It usually is advisable to place a rubber tissue drain beneath the skin and fat to prevent the accumulation of serosanguineous exudate. The drain may be removed within forty-eight hours. A pressure dressing is applied. An abdominal support is advisable.

OMPHALOCELE

General Considerations

In the presentation of this subject the teaching of Gross is followed. Operation for omphalocele is indicated immediately on the day of birth. If not operated upon,

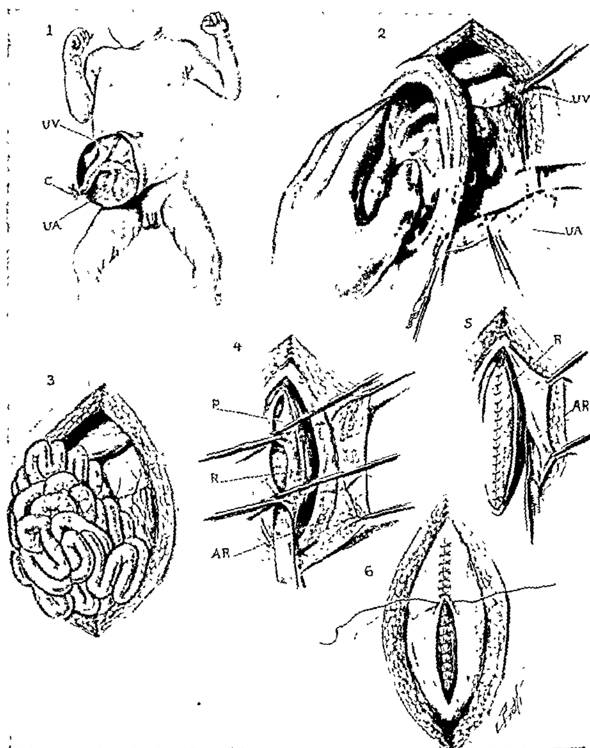


FIGURE 588 Technique of one-stage operation for small omphalocele *1*, Preoperative appearance. The omphalocele appears to be small enough for primary repair. *2*, The sac is removed with a narrow rim of skin and subsutaneous tissue sufficient to expose the rectus muscles The umbilical vein and arteries are ligated *3, The sac has been removed, exposing the viscera. 4, The viscera have been replaced in* the abdomen, and the peritoneal margins have been freed for suture *5*, The peritoneum has been closed with a continuous suture of fine chromic catgut *6*, The rectus muscles have been freed and united with interrupted sutures of silk The anterior sheaths of the rectus muscles are being sutured. Abbreviations: *AR*, *anterior rectus fascia, C, cord, P,* peritoneum, *ER*, rectus muscle; *UA*, *umbilical artery*, *UV*, umbilical vein (Gross The Surgery of Infancy and Childhood)

most infants die within a few days. Rupture of the thin sac and infection are the chief dangers of a waiting policy.

Dangers and Safeguards

If operation is postponed beyond the first day, the stomach and intestines are apt to become distended with gas, making repair much more difficult. If an omphalocele sac ruptures, peritonitis almost invariably develops. Formerly this complication was almost always fatal, but the use of antibiotics has improved the mortality rate.

Gross has warned that if the viscera are placed in the abdominal cavity under too much pressure, the diaphragm is displaced upward, resulting in respiratory disturbance and cyanosis; pressure on the inferior vena cava slows the return of blood from the lower abdomen and legs, causing circulatory collapse; and pressure on the stomach and intestines may initiate partial or temporary obstruction. These complications may cause death in twelve to thirty-six hours.

If the omphalocele is small, a primary one-stage repair may be made with a minimum of danger. If the omphalocele is large and has lost its right of domicile in the reduced capacity of the abdominal cavity, a two-stage operation is advisable.

In a series of seventy-eight babies treated surgically, Gross reported a mortality rate of 38 per cent. In a later portion of the series (1940 to 1950) the mortality rate was reduced to 34 per cent. Other congenital abnormalities played an important role in the mortality rate.

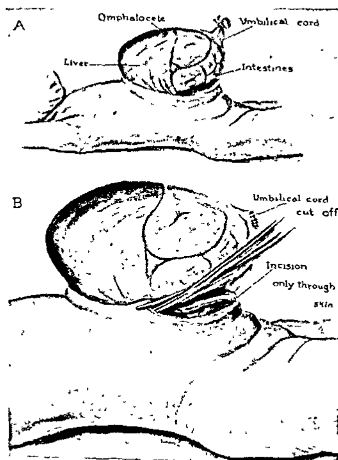


FIGURE 589. Technique of first stage of the 2-stage operation for large omphalocele. *A*, Appearance and size of omphalocele. *B*, Stump of umbilical cord has been removed and the base closed with sutures. The skin is being incised around the base of the sac. (Gross: The Surgery of *Infancy* and Childhood)

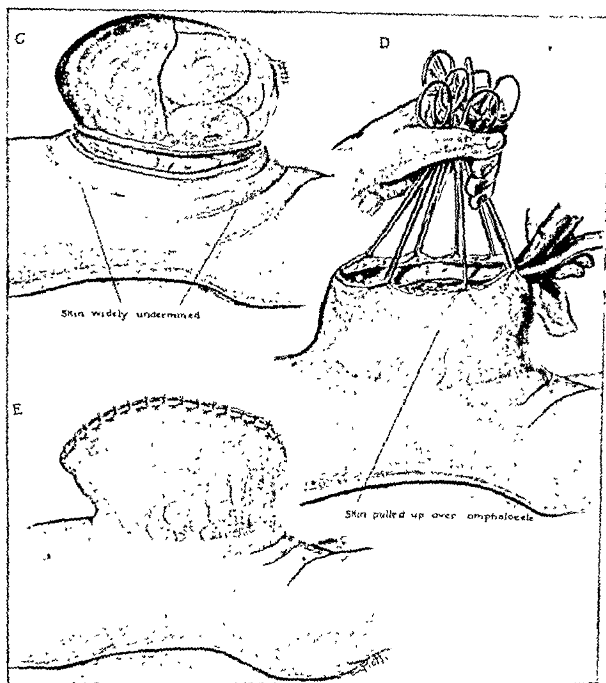


FIGURE 590 Technique of first stage of the 2-stage operation for large omphalocele (*concluded*). *C*, The margin of skin has been removed from the base of the sac with great care to avoid opening the sac. *D*, The skin has been undermined down to the pubis, into the flanks and a short distance over the lower chest The margins are held suspended with Allis clamps preparatory to closure *E*, The skin closed over the viscera without crowding them into the abdominal cavity. Closure is made with buried interrupted silk sutures in the subcutaneous tissues, reinforced with mattress sutures. The skin margin is closed with interrupted sutures. This method of closure gives broad apposition of subcutaneous surfaces (Gross The Surgery of Infancy and Childhood)

Technique of One-Stage Operation (Gross) (Fig. 588)

The sac is excised, and the margin of the abdominal ring is freed of its peritoneal covering. The two umbilical arteries and vein are ligated carefully. If possible, muscle and fascial layers about the ring should be separated to permit more accurate repair. The viscera should be carefully protected with moist saline packs during the dissection.

The difficult part of the operation is the abdominal wall closure. As the operation progresses it may become evident that complete abdominal wall closure will increase the intra-abdominal pressure to the danger point, and incomplete closure with the prospect of a second operation may be advisable.

The peritoneum and posterior rectus sheath should be closed together with a continuous suture or interrupted sutures. The mobilized muscles are approximated in the midline. The anterior rectus sheaths are closed, preferably by overlapping. If tension is too great, relaxing incisions may be made in the anterior sheaths of the rectus muscles. Interrupted sutures of silk are advised.

Technique of Two-Stage Operation (Gross) (Figs. 589 to 594)

First Stage. The skin is incised at the margin of the abdominal opening around the base of the omphalocele sac. The stump of the umbilical cord is removed, and its

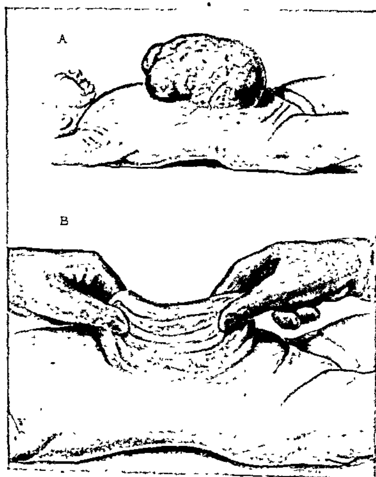


FIGURE 591. Technique of the second stage of the 2-stage operation for large omphalocele. *A*, Appearance of skin-covered visceral mass several months after the first operation. *B*, Demonstrating laxity of the abdominal wall. The viscera have been squeezed back into the abdomen. (Gross. The Surgery of Infancy and Childhood.)

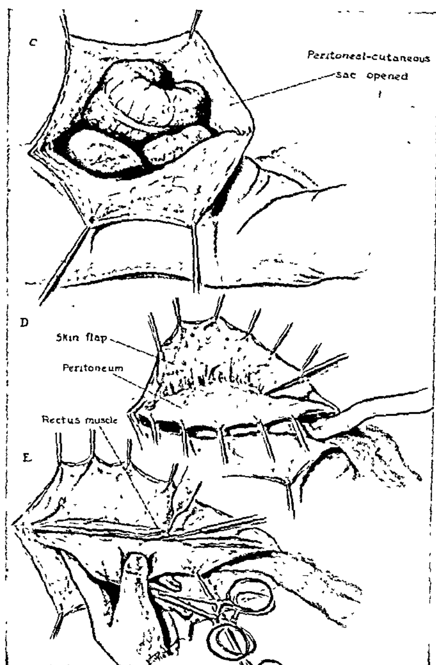


FIGURE 592 Technique of the second stage of the 2-stage operation for large omphalocele (*continued*). *C*, The sac is opened in the midline *D*, Abdominal wall flap and peritoneum held with Allis clamps Peritoneum is being separated from skin with sharp dissection *E*, The peritoneum is separated from skin until margin of muscle is identified and isolated (Gross· Surgery of Infancy and Childhood)

base is closed near the hernial sac. A wide undermining of the skin is then made down to the pubis and into the flanks. The undermining should not be extended much above the costal margin.

The omphalocele sac is left intact. The surface of this sac must be carefully cleansed with physiologic sodium chloride solution. Gross has advised the application of half-strength tincture of iodine (using 70 per cent alcohol as a diluent) to the surface of the sac. The undermined skin is closed over the omphalocele with interrupted silk sutures in the subcutaneous tissues and mattress sutures in the skin.

Second Stage. The time which should elapse between the first and the second stage must be judged by the condition of the patient. It may be as short as three to four months or it may be more than a year. As soon as there is laxity of the sac and

the viscera can be reduced into the abdomen by manipulation, the patient is ready for the second stage of the operation.

The sac is opened along its midline. The visceral adhesions are carefully divided until the entire sac wall is free. The peritoneum is separated from the skin by sharp dissection until the margins of the muscles are exposed. The peritoneal sac is cut away, leaving a margin around its base for closure.

The peritoneum is closed with a continuous suture of fine chromic catgut. The muscles are united with interrupted sutures of silk. After separating the anterior rectus sheaths from the underlying muscle they are united with interrupted sutures of silk. If there is sufficient laxity of the sheaths, they are overlapped and united with two rows of sutures. As the last step, the excess skin is cut away and the skin margins are united with interrupted sutures of silk. A light pressure dressing is applied.

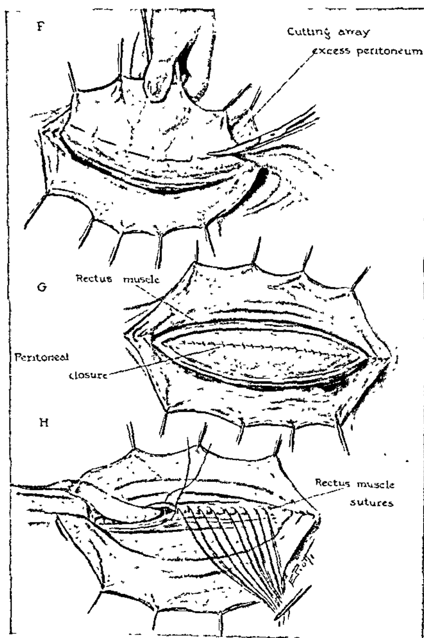


FIGURE 593 Technique of the second stage of the 2-stage operation for large omphalocele (*continued*). *F*, Excess peritoneum is being cut away along the dotted line. *G*, The peritoneum has been closed with a continuous suture of catgut. *H*, The rectus muscles being united with interrupted silk sutures. (Gross Surgery of Infancy and Childhood.)

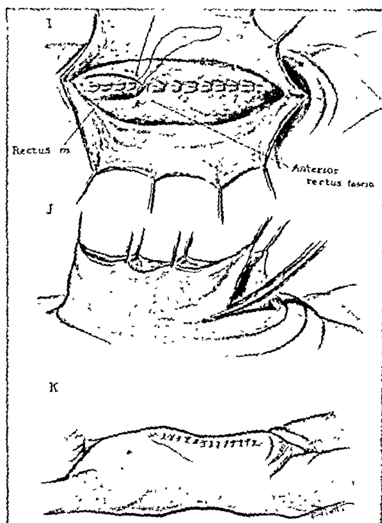


FIGURE 594 Technique of the second stage of the 2-stage operation for large omphalocele (*concluded*) *I*, Anterior rectus fascias have been freed and are being united with interrupted silk sutures. *J*, Excess skin being cut away *K*, The skin has been closed with interrupted sutures of silk. (*Gross*, Surgery of Infancy and Childhood)

OPERATIONS FOR DIAPHRAGMATIC HERNIA

General Considerations

Diaphragmatic hernias may be divided into congenital, acquired and traumatic types. Hernias through the diaphragm usually occur through esophageal, parasternal (foramen of Morgagni), paravertebral (foramen of Bochdalek), central, lateral or posterior openings (Fig. 595). They may or may not have sacs (true or false). Traumatic hernias usually occur through tears in the dome or posterior half of the left diaphragm. The contents of the hernia may be stomach, colon, small intestine, omentum, liver, spleen, pancreas, kidney or various combinations of these organs. A loop of bowel may be obstructed or strangulated

Operation is indicated when a diaphragmatic hernia produces symptoms. Operation is also indicated for large hernias of the congenital type found in early infancy and for all traumatic hernias. Hedblom has stated that 75 per cent of patients with congenital diaphragmatic hernia die before the end of the first month of life. Some of these babies can be saved if operated upon early. Children under one year of age tolerate the operation well if in good general condition.

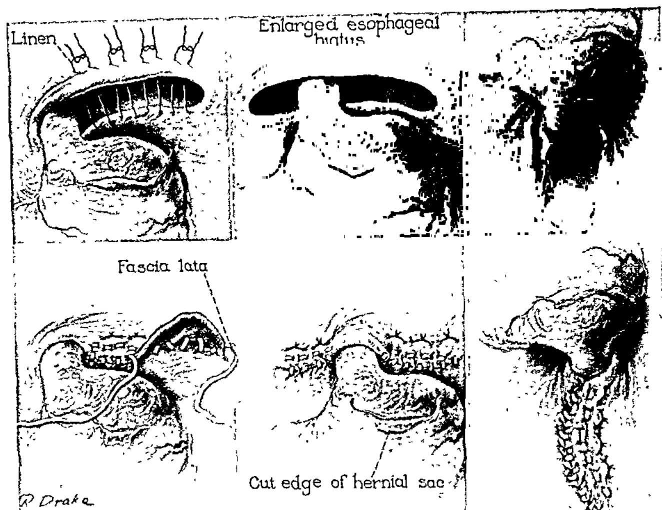


FIGURE 595. Technique of repair of diaphragmatic hernia. The more common types of structurally deficient esophageal openings which permit herniation of the stomach into the posterior mediastinum with method of repair of each type. (Harrington: West. J. Surg , Obst. & Gynec., Vol. 44)

Dangers and Safeguards

Nasogastric intubation of the stomach is essential to provide decompression and collapse of the upper intestinal tract. Anesthesia must be performed under endotracheal technique in order to maintain adequate pulmonary ventilation and to prevent aspiration of regurgitated gastric content. Injury to the esophagus or abdominal viscera may result in *mediastinitis* or *peritonitis*. *Obstruction of the bowel* is a dangerous complication. Fixation of the stomach or other viscera to the diaphragm by adhesions requires careful identification and dissection of cleavage lines to avoid injury to these structures.

Results of operation are good in a high percentage of cases. The mortality rate is high when diaphragmatic hernia is complicated by intestinal obstruction. Hedblom has recorded a mortality rate of 52.3 per cent in those cases complicated by obstruction and 21.1 per cent in the unobstructed cases. In a series of 225 patients reported by Harrington, operative mortality rate was 4 per cent.

Technique of Operation for Diaphragmatic Hernia (Figs. 596, 597)

As a preliminary procedure, crushing of the phrenic nerve is often indicated, especially if the hernial opening is large. This paralyzes the diaphragm for three to six months and makes suture of the hernial opening easier by relaxation and immo-

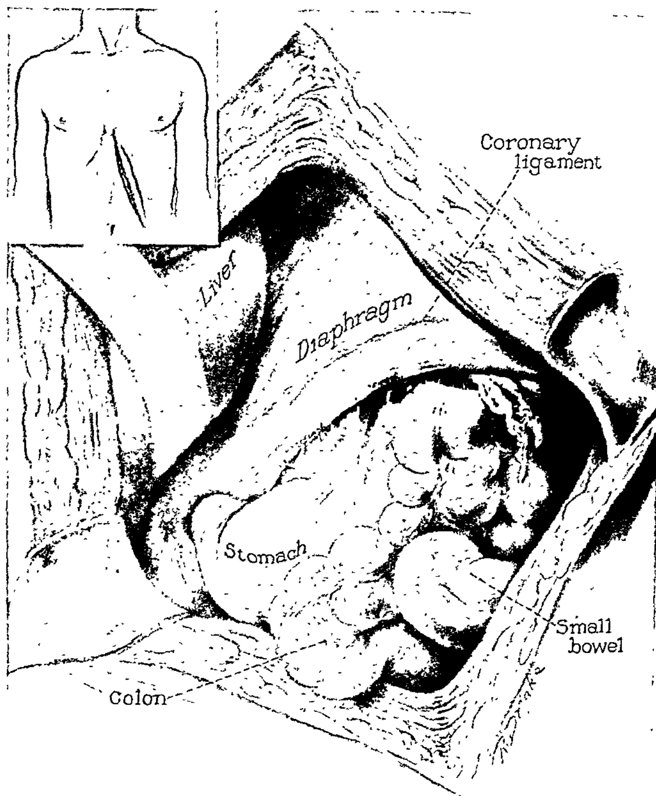


FIGURE 596 Technique of repair of a hernia through the diaphragm due to trauma. Insert shows type of incision used for abdominal approach Left coronary ligament cut and liver retracted. Stomach, colon, spleen and small bowel have herniated into the left thoracic cavity (Harrington· West. J. Surg, Obst & Gynec, Vol 44)

bility of the muscle. If the hernia is to be approached by the abdominal route, the patient should be placed on his back with a pillow support. For thoracotomy, he should be placed on the sound side with pillows to elevate the thoracic wall.

The operative route may be through the thorax or abdomen or by a combination of the two. Exposure is somewhat better by thoracotomy. Laparotomy is preferred for parasternal hernias.

Rib resection is rarely necessary for transthoracic hernial repair. A seventh intercostal incision usually affords ample exposure if made of sufficient length. It should begin at the costochondral junction and extend backward to the posterior axillary line.

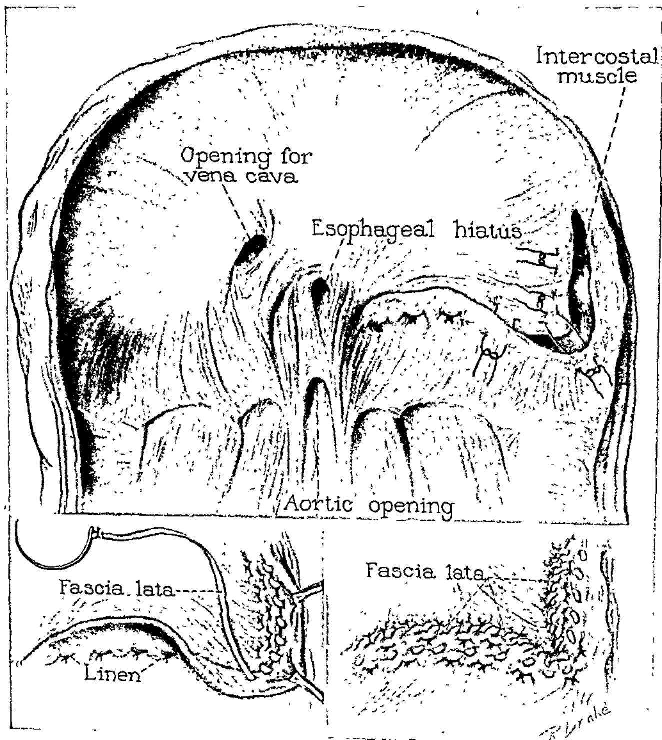


FIGURE 597. Technique of repair of rent in diaphragm with silk or linen and fascia lata. (Harrington: West. J. Surg., Obst. & Gynec., Vol 44.)

The ribs should then be spread apart with a self-retaining retractor. In rare cases reduction of the hernia may be impossible from above, and an abdominal incision becomes necessary for bimanual manipulation and replacement of viscera. The opening in the diaphragm is closed by imbricating its margins and suturing with a double row of silk mattress sutures. The thoracic wound is closed with interrupted silk sutures in the intercostal muscles, chest wall muscles, and fascia and skin. If the ribs are difficult to replace or hold in proper position, silver wire sutures may be used to encircle the ribs. Silver wire sutures may be removed after healing.

A satisfactory abdominal incision may be made below and parallel with the left costal margin from the costoxiphoid angle to the tip of the eleventh rib. A long paramedian incision will also give good exposure. The left lateral ligament of the liver is cut, and the left lobe of the liver is retracted to the right to aid exposure. The diaphragm is explored, and the hernial opening is identified. The herniated viscera are freed of adhesions and reduced. If necessary for reduction, the hernial ring may be enlarged. Negative pressure within the thorax may prevent reduction of the hernia. In such a case, pressure may be equalized by passing a finger or rubber tube past the margin of the ring into the pleural cavity.

The opening in the diaphragm should be closed by imbrication, using a double row of interrupted silk sutures. Harrington reinforces the suture line with sutures of fascia lata. The lung should be inflated before final closure of the wound. An abdominal wound is closed in the customary manner.

Technique of Operation for Diaphragmatic Hernia (Transthoracic) (Figs. 598-600)

The patient is placed upon the operating table in position for a left thoracotomy. This is accomplished over the seventh or eighth rib, which is removed subperiosteally.

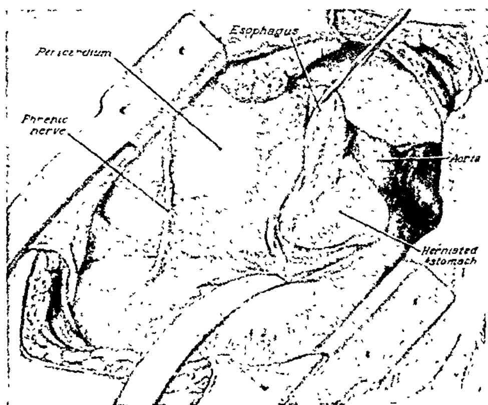


FIGURE 598 Exposure of hiatus hernia through transthoracic approach (C R Lam and L J. Kenney J. Thoracic Surg, Vol 27)



FIGURE 599 The stomach is retracted into the abdomen, and sutures are placed through the crura of the diaphragm posterior to the esophagus. (C. R Lam and L. J. Kenney: J. Thoracic Surg., Vol 27.)

An electrocautery is useful for providing hemostasis through this stage. After the chest has been opened a rib spreader is inserted, and the chest is spread to expose the diaphragm, lower esophagus and site of the hernia. The lung is carefully retracted out of the operative field and held in place with packs. It is usually necessary to divide the inferior pulmonary ligament between clamps in order to provide adequate mobilization of the lung. The mediastinal pleura is then opened to allow the esophagus to be mobilized for a distance of 4 to 6 cm. above the diaphragm. A tape is then passed around the esophagus to provide retraction. A small counterincision is then made in the dome of the diaphragm, and a clamp is passed along the under surface of the diaphragm, piercing the peritoneum near the anterior surface of the hiatus. This clamp grasps the tape which encircles the esophagus and draws it through the opening in the diaphragm. This maintains the stomach in a state of reduction during the repair of the hernia. The hernial sac is then excised, all fat and areolar tissue being cleaned off the diaphragm. Bleeding points must be carefully clamped and ligated. The repair in the defect of the diaphragm is accomplished by suturing the crura posterior to the esophagus with interrupted sutures of nonabsorbable material; usually four to six sutures are necessary.

Before tying these sutures, however, three or four mattress sutures are placed which approximate the esophagus to the under surface of the hiatus, which fixes the phrenoesophageal ligament to the abdominal surface of the diaphragm. The posterior sutures are then tied and a finger inserted in the orifice at the site of the esophagus to prevent closing of the hiatus too tightly. The tape is then removed from the counterincision in the diaphragm, which is then closed with interrupted sutures. The lung is then expanded, and the chest wall is closed in layers, using interrupted sutures of nonabsorbable material. Usually 000 cotton or silk is satisfactory for the periosteum



FIGURE 600 The hernia repair is nearly completed. The finger in the hiatus prevents too tight a closure. (C. R. Lam and L. J. Kenney: J. Thoracic Surg., Vol. 27.)

and the layers of chest muscles. Before closure, however, a stab wound is made in the ninth interspace in the midaxillary line, and a chest drainage catheter is inserted and attached to suction to maintain the lung in expansion and also to drain off any fluid which may accumulate as a result of operation.

The skin may be closed in whatever manner the surgeon desires, and an Elastoplast dressing is applied and suction maintained on the chest catheter for twenty-four to forty-eight hours or until there is evidence of cessation of function of the suction apparatus. It is recommended that in the early stages of the operation a phrenic crush be performed, which places the diaphragm at rest for a period of weeks or months following operation

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CHAPTER 15

Bones and Joints

General Principles

Operations upon bones and joints demand careful technique. Infection following operation may hopelessly ruin a well planned and executed surgical procedure and will undoubtedly increase the mortality rate. It is therefore obvious that the patient's general condition should receive special attention before an operation is planned. The part to be operated upon demands careful local preparation to avoid infection.

The *general preparation* of the patient does not differ from that advised for any major operative procedure. Such conditions as anemia, changes in body chemistry, dehydration, poor nutrition, chronic infections, diabetes, nephritis and myocarditis all have a bearing upon the patient's operability. Extensive bone and joint operations are so frequently followed by shock that this condition should always be guarded against by adequate preoperative administration of water and dextrose. Blood should be available for transfusions.

Local preparation for operation may require several days Scars and thickened and calloused skin harbor infection. Soaking, cleansing with soap and water, and soap poultices are useful in cleansing such tissue. Extensive bone operations should be postponed until old wounds have been healed for four to six months.

All preparation *in the operating room* should be done with scrupulous care. The wound should be well protected with drapings. To avoid loss of blood, improve viability, and hasten the operation, a tourniquet should be used when it can be applied without damage to the tissues. Because of the technical difficulties frequently met in bone surgery, there is a tendency to produce extensive trauma of the bone, periosteum and surrounding tissue. This should be avoided as much as possible, since devitalized tissue predisposes to infection and delayed healing. Careful hemostasis, a minimum of suture material, avoidance of mass ligations and suture tension are all general principles involved in wound healing which should be thoughtfully observed.

An *adequate surgical approach* is important. Darrach lists his criteria for a good surgical approach as follows: (1) It should provide comfortable access to the structures sought for; (2) it should do as little damage as possible; (3) it should pass between rather than through muscles, (4) it should pass muscles on the side opposite their

blood and nerve supply; (5) it should permit actual visualization of important structures or pass a safe distance from them; (6) it should be possible at the close of the operation to restore the disturbed structures to their normal positions and permit them to regain their normal functions as quickly as possible.

Before attempting surgery of bones, *a knowledge of bone physiology and pathology* is necessary. Without this knowledge, serious blunders may be made which may interfere with the development of growing bone, or the blood supply may be damaged until healing is impaired. The healing of bone differs very much from that of other tissues. The natural history of bone disease with a knowledge of what to expect when bone is infected or injured must be appreciated if therapy is to be logical and successful.

The judicious use of the *antibiotics* will undoubtedly reduce the incidence and severity of infections in bone surgery. However, *the use of any type of chemotherapy must not be considered a substitute for good surgery.*

Much of the success of bone and joint operations depends upon the *after-care.* Adequate splinting until bones are healed and physical therapy at the proper time are essential parts of bone surgery.

OSTEOMYELITIS

General Considerations

Pyogenic infections of the bone may be classified as acute, subacute or chronic. The infection may be of hematogenous origin or may be the result of contamination as occurs in compound fractures or following operation. The use of antibiotics has altered greatly the outlook and management of patients with hematogenous osteomyelitis. Indeed, all but a few cases respond to antibiotic therapy, never requiring operative intervention. However, in certain instances the offending organisms may be resistant to all antibacterial agents and require operative drainage. In addition, one may encounter an occasional case in which therapy has been delayed for such a long time that antibiotic therapy is no longer effective.

Technique of Incision and Drainage of Acute Osteomyelitis

General anesthesia is almost always necessary. The length of the incision depends upon the location of the disease, size of the patient, and extent of bone involvement. It should be made over the point of maximum tenderness. Usually an incision 7 to 10 cm. long is advisable. Nerves and blood vessels are protected.

The periosteum is frequently found detached from the bone with pus under pressure beneath it. If the periosteum is not already separated, it is elevated on each side of the incision to expose the bone. To avoid reducing the periosteal blood supply, the denuded area of bone should not be any larger than necessary for proper exploration. Drill holes are made in the cortex at the suspected site of infection. A small exploratory opening may be made with chisel or gouge. If pus is found, the opening should be enlarged to permit adequate drainage Extensive cutting away of bone is contraindicated. The infected bone marrow and pus may be gently removed, but excessive use of the curet is to be avoided. The primary object of the operation is to secure drainage and not to remove the infected bone.

The success of the postoperative treatment will depend much upon the care with

which it is administered. Some surgeons prefer the antiseptic treatment of Carrel-Dakin. Others have successfully used simple packing of the wound with iodoform or other antiseptic impregnated gauze.

Method of H. W. Orr. The treatment of choice for the average case of either acute or chronic osteomyelitis is probably that of H. W. Orr. He has enumerated the following principles upon which his treatment is based:

1. Make a fairly large incision over the infected bone area. Spread apart the skin, muscles, fasciae and periosteum just far enough to afford access to the diseased area and no farther.

2. Chisel a window into the affected bone area large enough so that all diseased bone may be removed and so that there are no overhanging edges of bone over the diseased area (less extensive in acute cases).

3. Clean out the diseased area gently with a curet or gouge, being careful to refrain from unnecessarily damaging the tissues undergoing repair.

4. Dry the wound and wipe out with 10 per cent iodine followed by 95 per cent alcohol.

5. Pack the entire wound wide open, but not tightly, with a sterile petrolatum gauze pack. Cover this with a dry sterile pad, and bandage on.

6. Now perform any reasonable forcible manipulation necessary to place the parts in correct anatomical position for splinting (abduct the arm to 90 degrees in humerus cases; dorsiflex and supinate the hand in forearm and wrist cases; dorsiflex the foot to a right angle with the leg in leg and foot cases).

7. Apply a plaster cast (preferable) or a suitable splint so that the parts are thoroughly immobilized in comfortable and correct positions. Additional weight and pulley traction, or even ice tongs or bone pins, may be used in infected bone lesions associated with fractures and old fracture deformities which are being corrected at the same time as the clean-up operation. It may be said that it is in the latter cases that some of the most gratifying results may be obtained by this method.

8. Finally, the cast is not to be split, nor are windows to be cut in the cast until the wound dressing becomes necessary. A dressing is indicated if there is a rise in temperature or other signs of acute infection. As a rule, no dressing is necessary, except on account of odor, and this may not be required for several weeks. In a majority of cases the patient treated by this method will go through to complete healing with a few dressings at intervals of ten days to four weeks.

Technique of Operation for Chronic Osteomyelitis (Sequestrectomy) (Fig. 601)

Operation is indicated when the x-ray film shows that a sequestrum has separated from the old bone and sufficient new bone (involucrum) has formed to maintain adequate strength for support and to prevent fracture. Removal of a portion of the bone shaft in the subacute stage is rarely indicated and should never be done without double bone support as in the leg and forearm.

A tourniquet is advised. The incision is made over the site of the nearest approach to the bone, when this is possible without endangering important structures. There are frequently sinuses and scars which should be removed, when practicable, with the primary incisions

FIGURE 601 Technique of sequestrectomy. *A*, Area to be removed is outlined with drill holes to prevent pathologic fracture when removing cortex with a chisel. *B*, Sequestra and chronic inflammatory tissue removed. *C*, Cross section of bone showing saucerization and petrolatum gauze packing. (Redrawn from Campbell's Operative Orthopedics, C. V. Mobsy Company.)

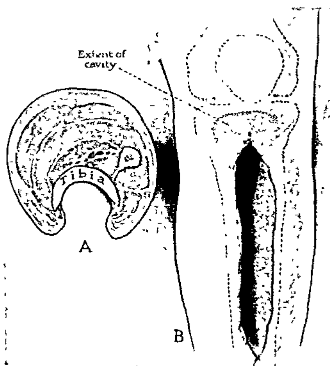


FIGURE 602. Plastic repair of chronic osteomyelitic cavity. *A*, Cross section through leg showing extent of defect in tibia *B*, View of longitudinal extent of cavity (Lord: Surg , Gynec & Obst , Vol. 60. By permission of Surgery, Gynecology and Obstetrics)

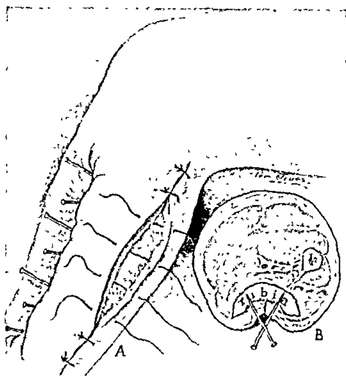


FIGURE 603. Plastic repair of chronic osteomyelitic cavity (*continued*). *A*, Skin folded into defect in bone and held with small nails Lateral incision to relieve tension B, Cross section of leg to show skin folded into defect and the position of nails in the bone. (Lord. *Surg., Gynec. & Obst , Vol 60. By* permission of Surgery, Gynecology and Obstetrics)

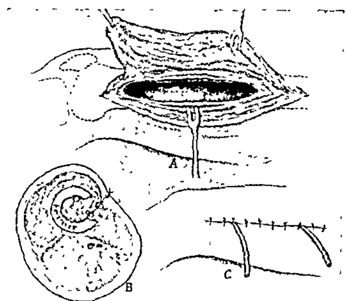


FIGURE 604. Plastic repair of chronic osteomyelitic cavity (*concluded*) *A*, Skin and *muscle flap reflected and bone guttered to re*ceive muscle flap *B*, Cross section of thigh to show muscle folded into defect in femur. *C*, Wound closed with drainage tubes in place. (Lord Surg , Gynec & Obst., Vol 60. By permission of Surgery, Gynecology & Obstetrics)

The periosteum is incised and elevated 1 to 2 cm. on each side. The exposed bone (involucrum) may be drilled to outline the section to be removed with a sharp chisel. After resecting the overlying bone, sequestra are removed, and the cavity is carefully explored with probe and curet for pockets and sinus tracts. All infected material should be removed. Small sequestra are easily overlooked. The involucrum should be saucerized as much as possible to permit soft tissues to fold inward to obliterate the space.

The *wound is packed open with petrolatum gauze after the method* of H. W. Orr, as previously described. An extremity is immobilized with a cast or splint.

Extensive scars and old bone cavities with recurrent ulceration may be treated with pedicled skin grafts or muscle flaps. A bone cavity *should be carefully prepared* before grafting is attempted. All dead bone and scar tissue should be removed down to healthy bleeding bone, and the cavity should be shaped to the best possible ad-

vantage for coverage with soft-parts. Raw bone should be covered, when possible, with muscle and full-thickness skin (Caldwell). Old deep gutters in bone may be obliterated by undermining and unfolding the skin, which is held in place by carpet tacks or small nails, as illustrated by Lord (Figs. 602, 603, 604).

OSTEOMYELITIS OF THE SKULL

General Considerations

Osteomyelitis of the skull may be the result of trauma, hematogenous infection, direct extension from infections of the nasal sinuses or mastoid, syphilis or tuberculosis. It may be localized or spreading. The common infecting organism is *Staphylococcus aureus.*

Infection may spread rapidly through the diploe, and the exact extent of the involvement be impossible to determine by the x-ray film. This makes the treatment of this type of bone infection very difficult. Localized osteomyelitis may form a sequestrum which is easily removed. To eradicate the spreading type, extensive removal of the skull may be necessary.

Complications of skull infection which may occur are extradural abscess, intracranial abscess, meningitis, and thrombosis of the dural sinuses.

Technique of Operation for Osteomyelitis of the Skull

A general anesthetic is usually required. The entire scalp should be shaved and prepared for operation. An incision is made over the infected area of sufficient length to give adequate exposure. The infected area is carefully explored to avoid injury to the dura. If a sequestrum is present, it should be removed without damage to its line of demarcation with normal bone. If the spreading type of infection is found, it is necessary to rongeur away the skull until the extent of the infection is reached. In some cases it may be necessary to remove large areas of bone.

Careful examination is made for infection of the dura or beneath the dura. Localized collections of pus are drained. The scalp is closed, and the wound is drained.

OPERATIONS UPON FRESH FRACTURES

General Considerations

Certain types of fracture are better treated by open operation, such as fractures involving joints, fractures with ends of bone separated, fractures with tissue interposed between fragments preventing reduction, and certain other fractures which may be reduced by manipulative methods, but cannot be held in reduction. Routine operation upon fresh fractures that can be reduced by the closed method is bad surgery.

Operation may be done immediately if the condition of the skin will permit. If the operation is to be postponed, it is advisable to wait for five to seven days until the swelling has subsided and the tissues have regained their vitality.

Technique of the Use of Local Anesthesia in the Reduction of Fractures

The part should be as carefully prepared as for open operation. One per cent procaine with 3 to 5 minims of epinephrine to the ounce is used. After anesthetizing a small area of the skin, the needle is passed into the gap between the bone fragments, injecting as the needle advances. If the point of the needle is in the proper place, bloody fluid can be aspirated. From 10 to 30 cc. of the anesthetic solution injected between and about the bone fragments is usually sufficient. After ten to fifteen minutes the fracture can be reduced with a minimum of pain.

Technique of Operation upon Long Bones (Figs. 605, 606)

A general or spinal anesthetic is used. If the operation is upon the femur, special apparatus, such as the Hawley table, is advised to hold the extremity and to apply traction. An incision is made over the site of the fracture in a position that will avoid injury to important structures, especially nerves. Towels are clipped on the wound margins to completely cover the skin. A fresh knife is used to continue the dissection to the bone.

Any soft tissue between the bone fragments is removed. The fracture is reduced by manipulation. A bone skid may be used when necessary. If the bone ends can be firmly engaged or a spicule of one fragment inserted into the medulla of the other to maintain fixation, the wound may be closed and a plaster cast applied.

When open operation is required to secure reduction of a fracture, some type of internal fixation to maintain reduction is usually necessary. Although many different

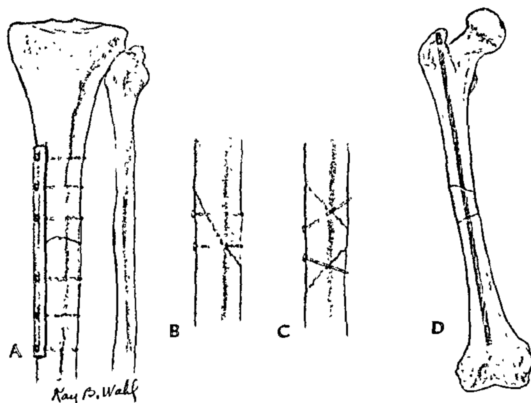


FIGURE 605 Methods of internal fixation of fractures *A*, Use of plate and screws for transverse or short oblique fractures *B*, Use of screws to transfix a long oblique or spiral fracture. *C*, Screws used to transfix butterfly fragment. *D*, Intramedullary nail transfixion.

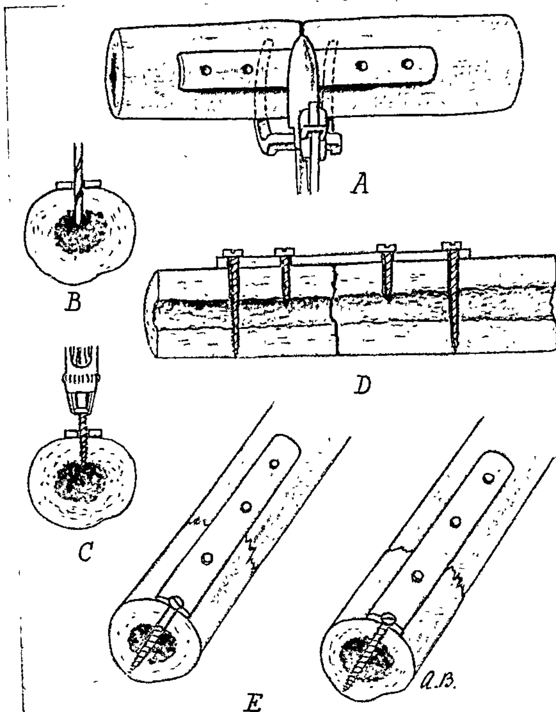


FIGURE 606 *A, B, C, D,* Method of maintaining reduction of a fracture with a metal plate *E,* Improper and proper types of screw If threads on screw do not extend entire length, only the distal cortex is engaged. (Redrawn from Campbell's Operative Orthopedics, C. V. Mosby Company.)

types of substances have been used for internal fixation, the most satisfactory means of maintaining reduction is either by use of metal screws, often in combination with various types of plates, or by the use of intramedullary pins or nails. The metals most widely in use are Vitallium or stainless steel. Metals of different types should not be used together because of the resultant electrolytic action. Even though these metals are essentially inert in tissue, it must be remembered that they are foreign bodies in the wound and may cause absorption of bone and may delay wound healing.

If a plate or screw of any type is to be applied, the bone ends are approximated in good position by bone-holding forceps while the plate and screws are placed. When

possible, the plate is fixed in position with a bone-holding forceps. Screw holes are drilled and the screws placed to engage the opposite cortex. The number and size of screws and/or plates will be determined by the type and location of the fracture site. If a plate is to be used, at least two screws on each side of the fracture site are necessary to avoid a resultant hinge action.

Periosteum, muscle, fascia and skin are closed. Drainage is not used. A plaster cast or suitable splint is applied to maintain external fixation in the proper position.

These materials are only temporary means of producing immobilization and stability until bony union has occurred. If solid union does not occur, the metallic fixation material will inevitably bend or break.

It may be necessary to remove metal plates or screws after the bone has healed. Plates that are placed on superficial bones should be removed, but those deep beneath the muscle may remain permanently in place.

For certain types of fractures, particularly those involving the shaft of the femur, the use of a metal nail or rod in the intramedullary canal to maintain alignment offers many advantages. To be suitable for the intramedullary nail technique a fracture should be sufficiently distant from the ends of the bone to ensure sufficient length for adequate fixation by the pin. Transverse or short oblique fractures are more suitable for stabilization by this method, although various types of comminuted fractures may lend themselves to treatment by this method. Intramedullary nails may be introduced by the blind method, using guide wires with fluoroscopy or repeated roentgenograms during insertion of the pin; however, operative exposure of the fracture site with insertion of the nail under direct vision is more satisfactory in most instances.

The resumption of mobility and function is possible at an earlier date by using intramedullary techniques than when plates and screws are used, although it must be remembered that the intramedullary nail is only a temporary means of obtaining stabilization of the fracture site and that full utilization of the part must await bony union of the fracture site. In most instances intramedullary nails must be removed after the occurrence of sound union.

Technique of Operation for Compound Fractures

Thorough débridement and careful cleansing are of paramount importance in the treatment of compound fractures and other types of open traumatic wounds. The ready availability of antimicrobial agents should in no way alter the ritual of thorough scrubbing and irrigation of the wound and removal of all devitalized tissue present. It is also important to obtain complete epithelial coverage of traumatic wounds whenever possible. It may be advisable in many instances to use a split thickness graft as a temporary epithelial dressing when tissue loss or swelling makes it impossible to obtain closure of the wound. The graft may be applied directly or may be used to cover a defect produced by constructing lateral flaps or skin incisions to allow primary closure. When the wound is unusually dirty, or when there is a long delay between the time of injury and the time when treatment is instituted, it usually is preferable to leave the wound open and rely on secondary closure or later closure with split thickness or flap grafts.

General or spinal anesthesia is usually advisable. A tourniquet is an advantage when bleeding is profuse.

The skin is shaved over a wide area and scrubbed thoroughly with soap or detergent and water. The open wound is next scrubbed, followed by thorough irrigation of all its parts with physiologic sodium chloride solution. Débridement is then done. The ragged and devitalized edges of the skin are cut away with a sharp knife. All loose tags of tissue and foreign bodies are removed. Fragments of bone are preserved for later replacement unless they are soiled with dirt or grease, in which case they are removed. After débridement the wound is again cleansed with soap or detergent and water and irrigated with sodium chloride solution.

All bleeding vessels are carefully ligated with fine catgut. Nerve and tendon injuries are repaired. The wound is closed with catgut sutures in the muscle and fascia and silk in the skin. If there has been much skin loss, a flap or lateral skin incision may be made so that the wound may be closed directly over the fracture, or a split skin graft may be used. Drainage is usually not necessary.

Internal fixation with foreign substances should be avoided when possible. Careful reduction and external fixation in a cast or splint, with or without skeletal traction, will usually make internal fixation unnecessary. Internal fixation with Vitallium or stainless steel plates or screws may be used.

Antigas and antitetanus treatment is given in all cases. If any infection develops, the wound should be promptly opened and drained.

Technique of Operation for Fracture of the Olecranon (Fig. 607)

Fractures of the olecranon process with separation of the fragments should usually be treated by open reduction and internal fixation so as to permit fairly early resumption of motion. The method of internal fixation depends upon the position of the fracture line, the degree of comminution and to some extent upon the age of the patient. The technique of circumferential wiring to be described is suitable when the fracture line is well proximal to the coronoid process. McKeever and Buck have pointed out that the proximal fracture may be removed and the triceps aponeurosis resutured to the fascia and the periosteum near the distal fracture line. This method

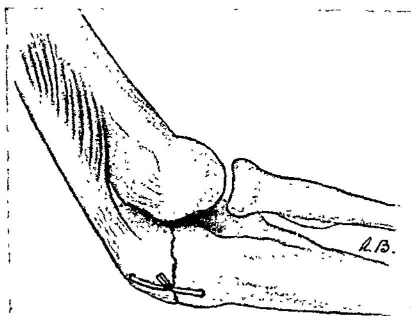


FIGURE 607. Technique of wiring a fracture of the olecranon.

is particularly applicable to comminuted fractures of the proximal olecranon and in cases in which nonunion has occurred. Certain complicated comminuted olecranon fractures may be treated with intramedullary nailing.

An incision 8 cm. long is made along the outer border of the olecranon. After the bone has been exposed a drill hole is made transversely through the lower fragment. Through this hole a stainless steel wire is passed. The wire is threaded on a heavy curved needle and passed around the tip of the olecranon through the triceps muscle tendon. The bone fragments are carefully manipulated into position and fixed by twisting the wire tightly. Heavy chromic catgut may be used as described above, or a second drill hole may be made in the upper fragment through which the ligature is passed. Wire is probably preferable to absorbable material. A stainless steel nail or screw passed through the upper fragment into the lower ulnar fragment is an efficient means of internal fixation. As after-treatment, a splint is applied with the arm flexed at a right angle. After a week, motion and physical therapy are started. The final result will depend upon the extent of joint injury. Motion may be limited, especially if traumatic arthritis develops.

Technique of Excision of Proximal Fragment of Fracture of the Olecranon (McKeever) (Fig. 608)

A longitudinal incision slightly to the ulnar side of the midline is made over the olecranon process extending 10 cm. below and 10 cm. above. The fascia is divided in a similar fashion and the ulnar nerve exposed and isolated sufficiently to transplant it anterior to the medial condyle. A U-shaped incision is made in the triceps aponeurosis with the base distal to the fracture site and the aponeurosis along with the proximal fragment elevated proximally. The proximal portion of bone is then excised with sharp dissection along with all remaining bone particles, and the remaining portion of the fracture line smoothed with rongeurs. With the elbow extended, the remaining tongue of the triceps aponeurosis is resutured under slight tension to the fascia from which it has been previously divided. The distal portion of the flap is further secured to the ulna by passing a few interrupted sutures through the fascia and periosteum. The ulnar nerve is transplanted to the anterior aspect of the medial condyle to prevent further injury. The elbow is flexed to determine the degree of tension present before closure of the superficial fascia and skin. The arm is immobilized at 110 degrees in plaster. The splint is removed at the end of three weeks, at which time motion is begun with gradual resumption of normal activity.

Technique of Operation for Fracture of the Head of the Radius (Fig. 609)

Although many fractures of the radial head may be treated successfully by conservative methods, operative excision of the head of the radius may be necessary to ensure a good functional result following healing. In general, those fractures which are comminuted or which involve the joint surface and those with sufficient angulation to interfere with rotation will have a better functional end result if the radial head is removed.

An incision 8 to 10 cm. long is made over the external condyle of the humerus extending downward over the radial head parallel with the shaft of the radius. The extensor carpi ulnaris and extensor digitorum communis muscles are separated, ex-

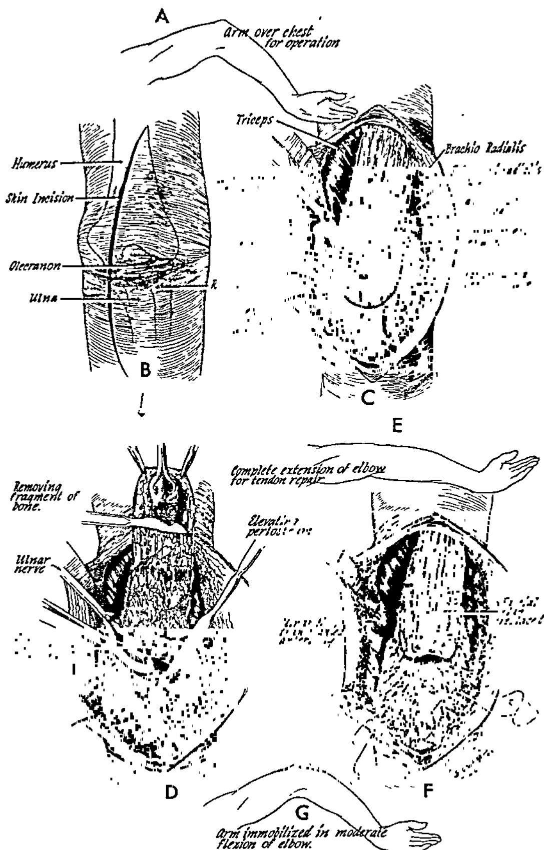


FIGURE 608 Excision of proximal fragment of fracture of the olecranon. *A*, Position of the arm *B*, Longitudinal skin incision slightly to the ulnar side of the midline *C*, The aponeurosis of the triceps muscle is incised as illustrated to form a flap *D*, Elevation of the flap and excision of the proximal fragment of the olecranon. The remaining fracture line is smoothed. *E*, Extension of elbow before repair of aponeurosis *F*, The flap of the aponeurosis is resutured to its original position under slight tension. This suture line is reinforced by sutures to the periosteum of the ulna *G*, The elbow flexed to 110 degrees and the skin closed. (F. M McKeever and R. M. Buck: J.A.M.A., Vol. 135)

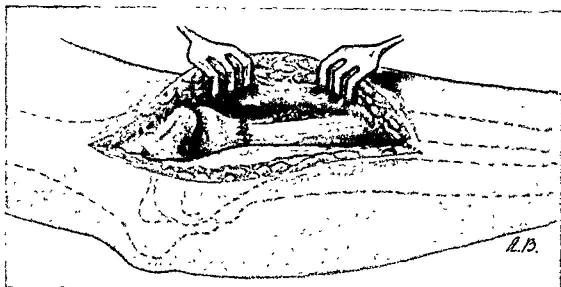


FIGURE 609 Technique of exposure of a fracture of the neck of the radius. (Redrawn from Campbell's Operative Orthopedics, C. V. Mosby Company.)

posing the bone It is necessary to open the posterior capsule of the joint to expose the head. Loose particles of bone are removed.

When there is comminution, the fragments with the neck are excised. The bone is severed with a Gigli saw or bone-cutting forceps above the point of attachment of the biceps muscle tendon. All periosteum as well as the annular ligament is carefully excised to prevent new bone formation which might prove troublesome later. The wound is closed without drainage.

The arm is splinted with the elbow at a right angle. After a week, motion and physical therapy are started. The ultimate range of motion may be complete, but limitation of motion, either in flexion or pronation and supination, may result.

Technique of Operation for Fracture of the Condyles of the Humerus (Fig. 610)

A medial or lateral incision is made 6 cm. long over the fractured condyle parallel with the shaft of the humerus The radial nerve is avoided on the lateral side, and the ulnar nerve on the medial side is carefully identified and retracted posteriorly to

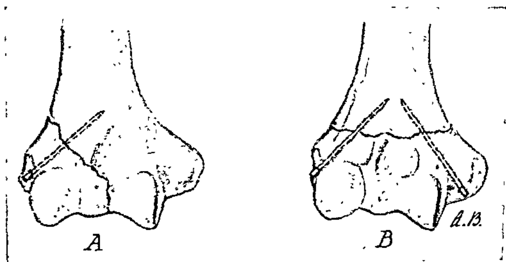


FIGURE 610. *A*, Fracture of condyle of humerus held in reduction [illegible] ail. *B*, Supracondylar fracture of the humerus held in reduction with 2 [illegible]

prevent injury. The condylar fragment is carefully inspected, and all small loose particles of bone are removed. The fractured condyle is manipulated into its normal position and held by a small stainless steel nail or threaded wire driven through the condyle into the humerus in a slightly upward direction. The wound is closed without drainage. A right-angled splint is applied for three weeks, at which time slight movement is begun. Active motion may be started in five-to six weeks. The position of the fragments and healing are checked with repeated roentgenograms. The nail may be removed after healing.

Technique of Operation for Supracondylar Fracture of the Humerus (Fig. 610)

This operation is indicated when reduction is not possible by manipulation.

An incision 6 cm. long is made over each condyle parallel with the humeral shaft. Injury to ulnar and radial nerves is avoided. Under direct vision the fragments can be manipulated into proper position.

In some oblique fractures the fragments may be fixed with stainless steel wire threaded through drill holes in the fragments. Fixation with stainless steel nails is satisfactory. A nail is driven through each condyle upward and inward into the shaft.

The after-treatment is the same as that described previously for condylar fractures. If reduction is accurate, good results may be expected.

Technique of Operation for Fracture of the Anatomical and Surgical Necks of the Humerus with Dislocation of the Head of the Humerus (Fig. 611)

Fractures of this type can seldom be reduced by the closed method. Early operative treatment is indicated.

An incision is made along the anterior border of the deltoid muscle downward from the clavicle a distance of about 10 cm. If sufficient exposure is not obtained, this incision is extended outward from its upper extremity, and the deltoid is incised along its clavicular attachment. The deltoid and pectoralis major muscles are separated to expose the joint.

The dislocated upper fragment usually lies anterior and beneath the coracoid process. By careful manipulation the dislocation is reduced through the rent in the capsule. If the anatomical neck has been fractured, the head of the humerus may be free in the tissue. A fracture or epiphysial separation below the head will have soft tissue attachments.

After reduction the upper fragment will usually remain in position after external fixation. If internal fixation is necessary, stainless steel wire may be passed through drill holes in the fragments. The joint capsule is always sutured.

Injury to the axillary vessels and nerves must be carefully avoided when manipulating the dislocated upper fragment. The wounds in the muscle and skin are closed without drainage.

The arm is fixed in a plaster shoulder spica in abduction and slight external rotation. The degree of abduction necessary to maintain proper alignment of bone fragments varies.

After four weeks the cast is removed, and passive motion is begun. If union is not firm, some type of aeroplane splint is worn until healing is sufficiently advanced to prevent displacement.

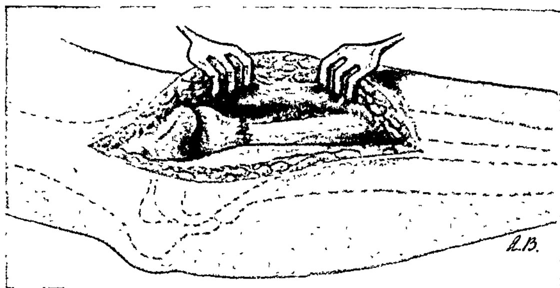


FIGURE 609. Technique of exposure of a fracture of the neck of the radius. (Redrawn from Campbell's Operative Orthopedics, C. V. Mosby Company.)

posing the bone. It is necessary to open the posterior capsule of the joint to expose the head. Loose particles of bone are removed.

When there is comminution, the fragments with the neck are excised. The bone is severed with a Gigli saw or bone-cutting forceps above the point of attachment of the biceps muscle tendon. All periosteum as well as the annular ligament is carefully excised to prevent new bone formation which might prove troublesome later. The wound is closed without drainage.

The arm is splinted with the elbow at a right angle. After a week, motion and physical therapy are started. The ultimate range of motion may be complete, but limitation of motion, either in flexion or pronation and supination, may result.

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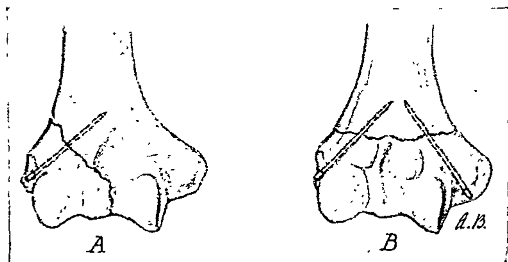


FIGURE 610. *A*, Fracture of condyle of humerus held in reduction with wire nail *B*, Supracondylar fracture of the humerus held in reduction with 2 wire nails

prevent injury. The condylar fragment is carefully inspected, and all small loose particles of bone are removed. The fractured condyle is manipulated into its normal position and held by a small stainless steel nail or threaded wire driven through the condyle into the humerus in a slightly upward direction. The wound is closed without drainage. A right-angled splint is applied for three weeks, at which time slight movement is begun. Active motion may be started in five to six weeks. The position of the fragments and healing are checked with repeated roentgenograms. The nail may be removed after healing.

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After reduction the upper fragment will usually remain in position after external fixation. If internal fixation is necessary, stainless steel wire may be passed through drill holes in the fragments The joint capsule is always sutured.

Injury to the axillary vessels and nerves must be carefully avoided when manipulating the dislocated upper fragment The wounds in the muscle and skin are closed without drainage.

The arm is fixed in a plaster shoulder spica in abduction and slight external rotation. The degree of abduction necessary to maintain proper alignment of bone fragments varies

After four weeks the cast is removed, and passive motion is begun. If union is not firm, some type of aeroplane splint is worn until healing is sufficiently advanced to prevent displacement.

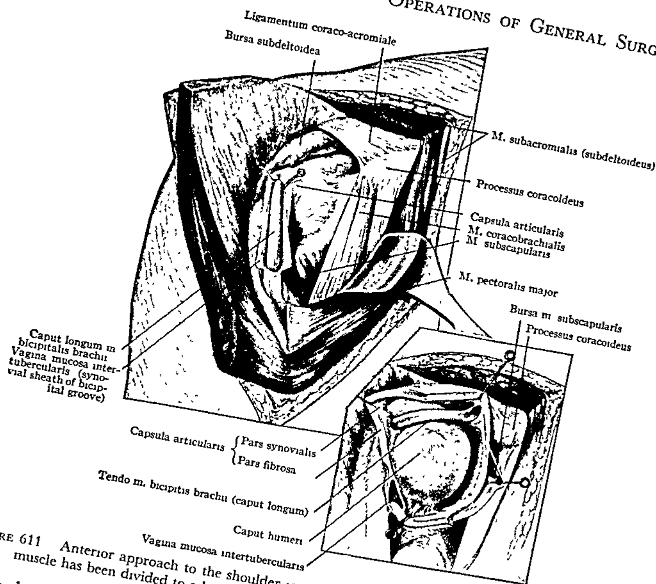


FIGURE 611 Anterior approach to the shoulder joint Much of the clavicular insertion of the deltoid muscle has been divided to adequately expose the joint (Callander: Surgical Anatomy.)

Technique of Operation for Fracture of the Patella (Fig. 612)

A transverse incision curved to pass over the lower border of the patella is made about 8 cm. long. The skin margins are freed, and the rent in the joint capsule is exposed throughout its length. Fragmented capsule and all completely detached fragments of bone are removed. If the fracture is comminuted, the joint should be

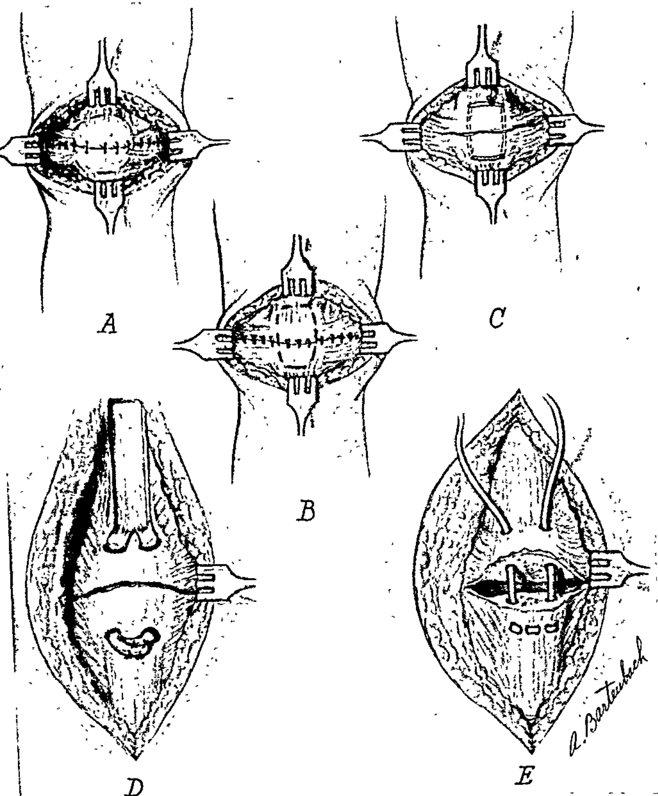


FIGURE 612. *A*, Fixation of fractured patella with circumferential wire loop and catgut sutures. *B*, Dengre Martin method of open reduction of fracture of the patella. Fragments are fixed with a wire loop, and tear in the capsule is sutured with catgut *C*, Magnuson method of wiring a fractured patella *D*, Ober technique of open reduction of fractured patella Two strips are cut from the quadriceps tendon, passed through drill holes in the patella and fixed with silk sutures. *E*, Thompson's technique of operation for fractured patella The smaller distal fragment is removed, and the patellar tendon is sutured to the upper fragment with a strip of fascia lata (Redrawn from Campbell's Operative Orthopedics, C. V. Mosby Company)

When the fragment is reduced, the nails are driven into the opposite condyle, and the condyles are impacted together. The wound is closed with fine catgut.

A plaster cast is applied from the ilium to the toes with the knee in slight flexion. After three or four weeks a caliper splint is fitted to permit physical therapy and slight motion at the knee. Union is usually firm enough to permit weight-bearing at the end of three months.

Technique of Operation for T-Fracture of the Condyles of the Femur (Fig. 615)

An incision 10 cm. long is made over the lateral aspect of the lateral condyle, extending upward from the joint parallel with the femur. The fascia is incised, and the fibers of the vastus lateralis muscle are separated, exposing the bone.

Manipulation and traction are frequently necessary to free the shaft of the femur from between the fractured condyles. The condyles are manipulated into position and nailed together with two steel nails or Knowles pins placed at slightly different angles. The reduction is checked by the x-ray film, and any adjustment necessary is made before the wound is closed.

A Kirschner wire may be inserted through the upper end of the tibia and incorporated in the plaster cast. A plaster spica is applied from the ilium to the toes after alignment of the femoral fragments. The knee is slightly flexed. X-ray films are again taken to determine the position of the fragments. After eight weeks the cast is removed, and a caliper splint is fitted. This will permit slight motion and physical therapy. Weight-bearing is not permitted until union is solid, which may require five to six months.

Technique of Fixation of Fracture of the Neck of the Femur with Smith-Petersen Nail (Fig. 616)

Spinal or general anesthesia may be used.

As special equipment, various sizes of Smith-Petersen nails, drill, guide pins, driver, impactor and extractor should be available. A fracture table designed to hold the leg in position after manipulation is helpful, although this can be done by an assistant.

After reducing the fracture by manipulation, an x-ray picture is taken in anteroposterior and lateral positions. A metal rule or measuring rod is placed over the normal hip when the film is taken to estimate the length of the nail needed. An assistant to hold the leg in position or to manipulate the leg as directed should be available during the operation.

The *Watson-Jones technique* is less formidable than the original Smith-Petersen operation and is here described. An incision is made about 10 to 12 cm. long with its midpoint over the anterior portion of the trochanter, which separates the tensor fasciae femoris and gluteus medius muscle. The trochanter may be separated, but this is not always necessary and causes excessive bleeding. The joint capsule is incised along the upper border of the neck, dissected from the intertrochanteric line, and turned forward as a triangular flap. By separating the upper fibers of the vastus externus subperiosteally, a clear view of the neck is obtained. The periosteum is stripped from the bone below the trochanter. When the fragments in alignment are under

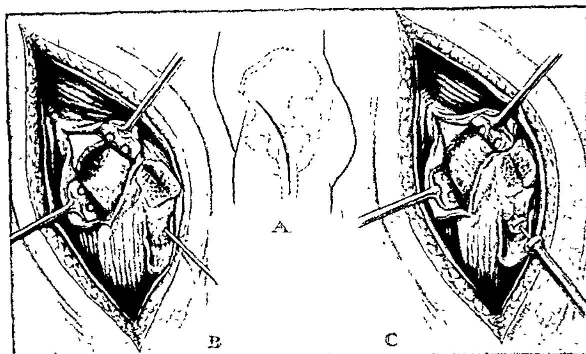


FIGURE 616. Watson-Jones technique of open operation for fracture of the neck of the femur, using the Smith-Petersen nail. *A*, Watson-Jones incision *B*, Exposure of fracture site and insertion of guide pin. *C*, Reduction completed with Smith-Petersen nail in place. (Campbell. Operative Orthopedics, C. V. Mosby Company)

direct vision, a guide pin is inserted through the lateral surface of the femur below the trochanter into the head. If the pin is not in good position after the first insertion, it is removed and reinserted After the guide pin has been satisfactorily placed, the Smith-Petersen nail is threaded on the pin and driven in. An impactor may be used to close the gap between the fragments. The wound is closed by suturing back into proper position the tissues divided.

Blind nailing has been used with success by some surgeons. The method used by Campbell is described (Figs. 617, 618).

After the fracture has been reduced by the Whitman and Leadbetter manipulations, confirmed by x-ray, an incision about 10 cm. long is made over the trochanter parallel with the femur. A steel wire 2.5 mm. in diameter is inserted into the femoral neck about 2 cm. below the trochanter with an ordinary chuck drill. The wire should form an angle of about 45 degrees with the shaft of the femur and about 15 degrees forward to conform to the normal position of the femoral neck. After inserting the wire 7 cm., its position is checked with the x-ray. If improperly placed, it is removed and reinserted. When the position is satisfactory, the wire is extended into the head of the bone to within 0.5 cm. of the joint surface. The position is again checked by the x-ray. A Smith-Petersen nail is threaded over the wire and driven in with a tunnel driver and mallet. The fragments are finally approximated by tapping the driver placed on the surface of the trochanter.

The nail should be inserted to within about 0 5 cm. of the joint surface of the femoral head. The position is determined by x-ray. The wound is closed without drainage.

Passive motion is started on the second day, and elderly patients may be out of

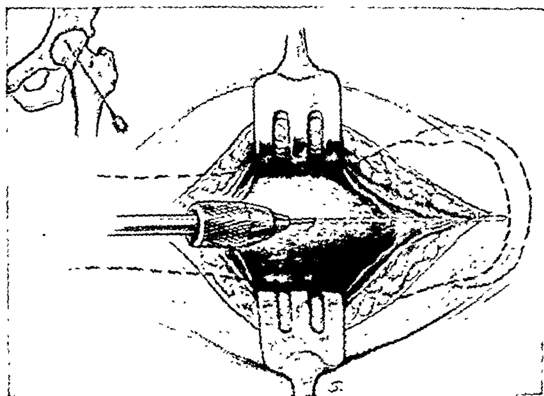


FIGURE 617. Technique of insertion of Smith-Petersen nail by blind method. Guide pin is inserted to within ¼ inch of articular surface of head of femur. This is checked by roentgenograms in both lateral and anteroposterior planes. (Campbell: Operative Orthopedics, C. V. Mosby Company.)

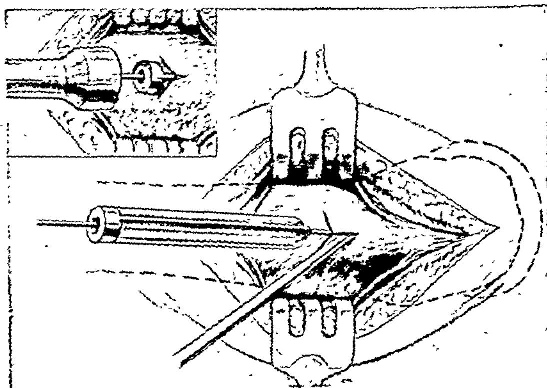


FIGURE 618. T[illegible] expedite insertion of [illegible] pin. (Campbell, Op[illegible]

bed and in a wheel chair on the second postoperative day. Active motion is resumed gradually. Walking on crutches is begun at twelve weeks, depending upon the roentgenologic findings, and partial weight-bearing is allowed at sixteen weeks. In most cases walking may be resumed at six months.

OPERATIONS FOR DELAYED UNION AND NONUNION OF FRACTURES

General Considerations

It is frequently difficult to differentiate between delayed union and nonunion of fractures. The time elapsing after the injury is not always a guiding factor. By careful study of repeated roentegenograms, cessation of healing can usually be determined. Clinical and x-ray evidences of pseudarthrosis, fibrous union, sclerosis of the bone ends and osteoporosis of the bone shafts are important points in the differentiation between delayed healing and definite nonunion. After the lapse of six months without union there is always a suspicion of nonunion, although union may result after a much longer period.

Delayed union is usually treated conservatively with proper fixation. If reduction is faulty or if there is evidence that soft parts may be interposed between the bone ends, open operation is indicated relatively early. By drilling the ends of the bone across the line of fracture, osteogenesis may be stimulated by increasing the circulation.

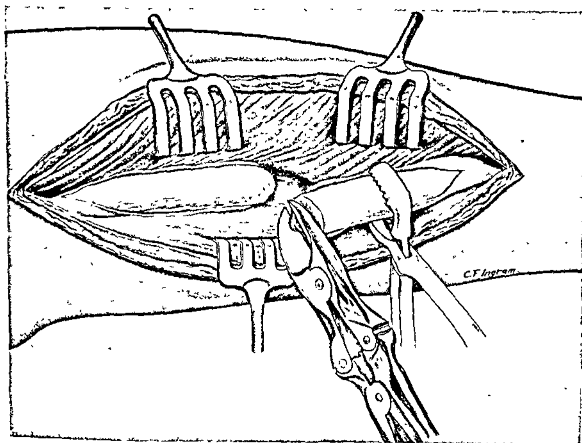


FIGURE 619 Technique of onlay bone graft for delayed union or nonunion of fracture. Excision of eburnated bone from ends of fragments Soft tissue attachments to bone are carefully preserved. (Campbell Operative Orthopedics, C. V Mosby Company.)

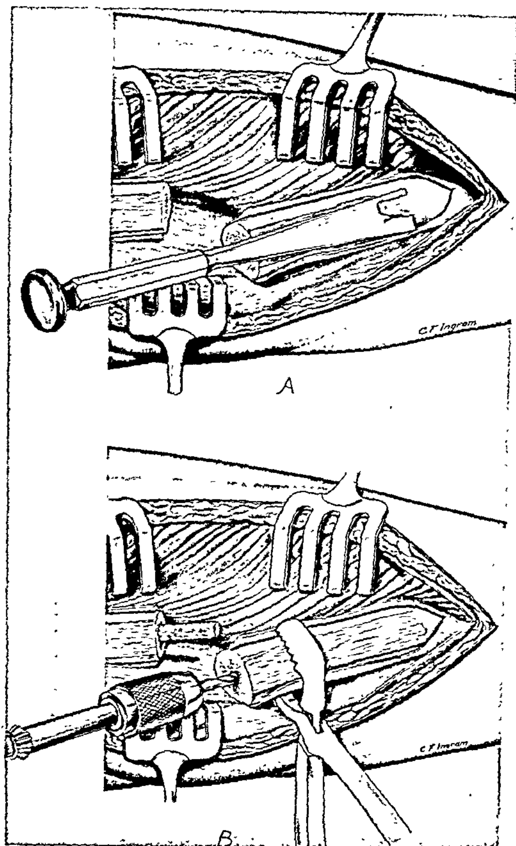


FIGURE 620 Technique of onlay graft for delayed union or nonunion of fracture (*continued*). *A*, A flat surface is made on each fragment a distance of 3 to 4 inches *B*, Each medulla is reamed out, and a graft of endosteum is placed in the medullary canal as the fracture is reduced. (Campbell: Operative Orthopedics, C V. Mosby Company.)

When nonunion is definitely established, open operation is indicated. The treatment of choice is by autogenous bone graft of the massive onlay or inlay type.

The use of *penicillin* preoperatively and postoperatively will reduce the incidence of infections. The work of Abbott and his associates indicates that nonunion of fractures which still harbor infection may be successfully treated by grafts if the patient is given large doses of penicillin before and after operation. Carpenter believes that chemotherapy plays an important role in bone graft surgery, but advises a delay of approximately three months after complete wound healing before operation.

Technique of Bone Grafting with Massive Onlay Graft (Campbell) (Figs. 619 to 622)

A long incision is made to expose the bone adequately. All scar tissue between the bone ends is removed, and sclerosed bone ends are cut away with shears or saw to expose normal medulla. If the apposition of the fragments is perfect, the bone ends are not disturbed. Periosteum is separated from the circumference for ½ to ¾ inches. The medulla may be reamed out to normal marrow tissue if sclerosis is present. The surface of the bone is then shaved with a chisel until a flat surface for the graft is obtained 8 to 10 cm. long on each fragment.

A full-thickness cortical graft of sufficient width and length is then taken from the tibia. Considerable time can be saved if this graft is obtained by a second team while the area to be grafted is exposed and prepared. The graft is then split longitudinally, using a motor saw, into two parts, one consisting of the outer cortical bone and the other of the endosteal bone.

A section of the endosteal bone is then placed in the medulla across the bony defect. The cortical graft is next placed on the prepared flat surface of the bone and held by a bone clamp. Two ⅛-inch holes are then drilled through the graft 1 inch

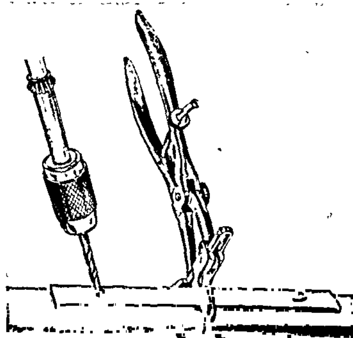


FIGURE 621. Fragments and cortical graft held in position by a bone clamp. Fixation secured by screws which traverse the graft and both cortices. (Campbell: Operative Orthopedics. St. Louis, C. V. Mosby Company.)

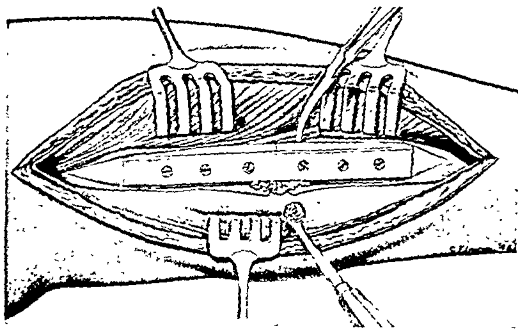


FIGURE 622. Onlay bone graft completed by insertion of cancellous bone about the fracture site from the medullary surface of the graft and from the tibial condyle. (Campbell: Operative Orthopedics. St. Louis, C. V. Mosby Company.)

from each end, the drill continuing through both cortices of the bone being repaired. Appropriate screws are then inserted. When the alignment and degree of impaction have been rechecked, two or more additional holes are drilled and screws inserted, depending upon the size of the bone being repaired.

Spongy bone is then removed from the condyles of the tibia with the curet through the defect left by the removal of the graft. This cancellous bone, bone shavings and the remaining portion of the medullary graft are placed around the site of the fracture. The wound and the soft tissue and skin are closed.

The after-treatment is important. A plaster cast is applied which may be bivalved to prevent constriction by postoperative swelling. The cast is changed in about three weeks. This is followed in eight to ten weeks by a brace, at which time active and passive motion usually may be started. The brace is worn two to four months, and during this period the patient may be ambulatory. The progress of healing is checked frequently by roentgenograms. Weight-bearing is permitted when healing is complete.

Technique of Bone Grafting with the Inlay Graft (Albee) (Fig. 623)

A long incision is made over the site of the fracture, exposing the bone, when possible, a distance of 15 to 20 cm. The periosteum is incised and separated from the bone in the area to be grafted. Scar tissue is removed, and the bone ends are freshened with chisel or saw.

Sliding Inlay Graft. The fragments are held in alignment while the graft is cut with an electric twin saw. The short fragment is cut about 7 to 8 cm. long and the long fragment 12 to 15 cm long. When the bone fragments are of unequal length, the long portion of the graft is cut from the long fragment. The ends of the graft are cut across with a small electrically driven saw, and the graft is removed from its bed with a chisel or osteotome.

Holes are drilled in each side of the graft bed through which are passed steel wire or heavy chromic catgut sutures. The long and short ends of the graft are re-

versed so that the long graft will bridge the defect in the bone. If the graft does not fit firmly, bone pegs may be fashioned and driven into drill holes in the cortex on each side of the graft, or metal screws may be used.

Inlay Graft. For the smaller long bones, an inlay graft taken from the tibia is often more satisfactory than the sliding graft (Fig. 623).

The bone and graft bed are prepared as for the sliding graft. A graft from the tibia is cut with a twin saw to fit the prepared graft bed. The graft is fixed in place as described above.

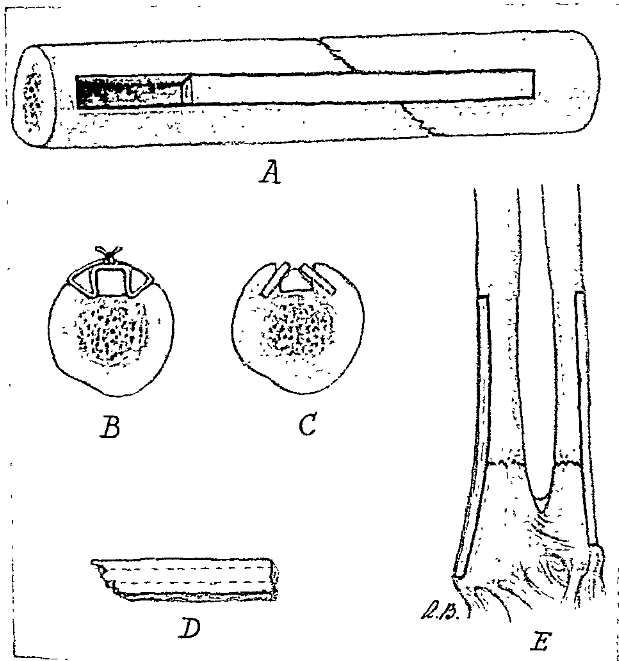


FIGURE 623. Technique of the Albee inlay graft for fractures. *A*, Graft cut with twin saws from proximal fragment and slid across point of fracture *B*, Drill holes have been made along the margin of the gutter in the bone through which has been passed a heavy suture of kangaroo tendon or chromic catgut. The suture is firmly tied to hold the graft in position. *C*, This illustrates the use of bone dowel pegs to hold graft in position *D*, Distal short fragment of bone removed with twin saws. This is used to fill defect in bone after sliding the long graft across the site of fracture. *E*, Inlay grafts cut from tibia, used for fractures of the ulna and radius

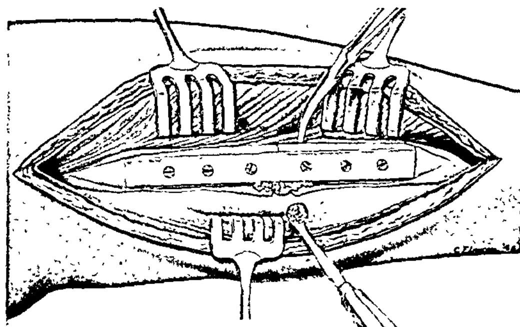


FIGURE 622 Onlay bone graft completed by insertion of cancellous bone about the fracture site from the medullary surface of the graft and from the tibial condyle. (Campbell: Operative Orthopedics. St. Louis, C. V. Mosby Company.)

from each end, the drill continuing through both cortices of the bone being repaired. Appropriate screws are then inserted. When the alignment and degree of impaction have been rechecked, two or more additional holes are drilled and screws inserted, depending upon the size of the bone being repaired.

Spongy bone is then removed from the condyles of the tibia with the curet through the defect left by the removal of the graft. This cancellous bone, bone shavings and the remaining portion of the medullary graft are placed around the site of the fracture. The wound and the soft tissue and skin are closed.

The after-treatment is important. A plaster cast is applied which may be bivalved to prevent constriction by postoperative swelling. The cast is changed in about three weeks. This is followed in eight to ten weeks by a brace, at which time active and passive motion usually may be started. The brace is worn two to four months, and during this period the patient may be ambulatory. The progress of healing is checked frequently by roentgenograms. Weight-bearing is permitted when healing is complete.

Technique of Bone Grafting with the Inlay Graft (Albee) (Fig. 623)

A long incision is made over the site of the fracture, exposing the bone, when possible, a distance of 15 to 20 cm. The periosteum is incised and separated from the bone in the area to be grafted. Scar tissue is removed, and the bone ends are freshened with chisel or saw.

Sliding Inlay Graft. The fragments are held in alignment while the graft is cut with an electric twin saw. The short fragment is cut about 7 to 8 cm. long and the long fragment 12 to 15 cm. long. When the bone fragments are of unequal length, the long portion of the graft is cut from the long fragment. The ends of the graft are cut across with a small electrically driven saw, and the graft is removed from its bed with a chisel or osteotome.

Holes are drilled in each side of the graft bed through which are passed steel wire or heavy chromic catgut sutures. The long and short ends of the graft are re-

versed so that the long graft will bridge the defect in the bone. If the graft does not fit firmly, bone pegs may be fashioned and driven into drill holes in the cortex on each side of the graft, or metal screws may be used.

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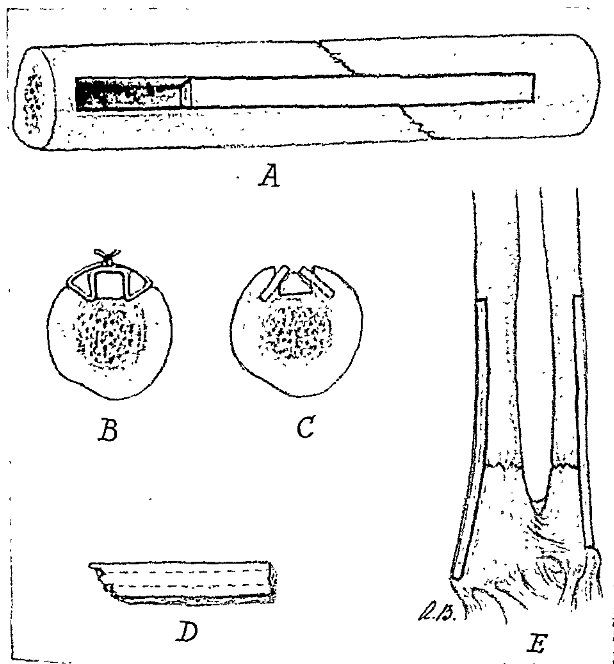


FIGURE 623 Technique of the Albee inlay graft for fractures *A*, Graft cut with twin saws from proximal fragment and slid across point of fracture *B*, Drill holes have been made along the margin of the gutter in the bone through which has been passed a heavy suture of kangaroo tendon or chromic catgut. The suture is firmly tied to hold the graft in position. *C*, This illustrates the use of bone dowel pegs to hold graft in position *D*, Distal short fragment of bone removed with twin saws. This is used to fill defect in bone after sliding the long graft across the site of fracture. *E*, Inlay grafts cut from tibia, used for fractures of the ulna and radius

OSTEOTOMY FOR BONE DEFORMITIES

Osteotomy is frequently indicated for the correction of such deformities as bow-legs (genu varum), knock-knees (genu valgum), malunion of fractures, ankylosis of joints in faulty position, torsions, coxa vara, stabilization of the foot, and the lengthen-

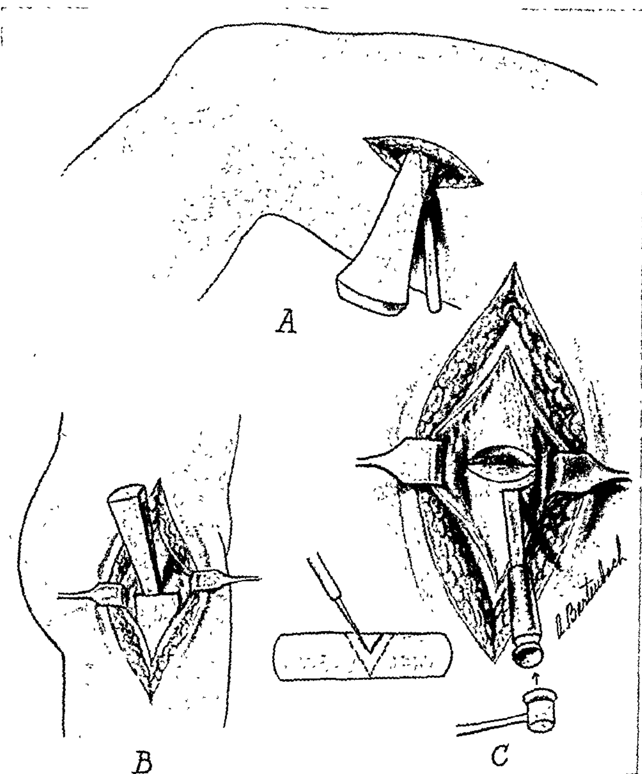


FIGURE 624 *A*, Technique of subcutaneous linear osteotomy A short incision is made to the bone. The osteotome is introduced with the knife as a guide To cut the bone, the osteotome is turned transversely when in contact with the bone *B*, Open method of osteotomy An incision is made, exposing the bone, and the bone is divided under vision *C*, Technique of open cuneiform osteotomy with a chisel. (Redrawn from Bickham Operative Surgery)

ing or shortening of bones. When contractures of soft structures are associated with bone deformity, tenotomy, fasciotomy, myotomy or capsulotomy may be a necessary part of the operation to permit correction.

Injury to nerves and blood vessels must be avoided. The danger of nonunion following osteotomy exists, but healing will usually result with proper after-treatment.

Technique of Linear Osteotomy

General anesthesia is usually necessary. The extremity is placed on a sandbag which is carefully covered with sterile towels.

Subcutaneous Method. An incision is made just long enough to admit the osteotome in a location to permit access to the bone by the most direct route with the least tissue damage.

An osteotome somewhat narrower than the diameter of the bone is passed beside the knife blade (Fig. 624). With the osteotome in contact with the bone, it is rotated to the position desired (usually transverse to the bone). It is held firmly in one hand and directed away from important structures. As the bone is severed, the osteotome is frequently shifted to prevent binding. As the incision in the bone progresses, it may be advisable to change to a thinner-bladed osteotome. The bone should be divided completely with the exception of the opposite cortex, which may be bent or broken by manipulation.

Open Method. An incision is made at the nearest approach to the bone. When possible, the periosteum is divided parallel with the bone and separated with an elevator (Fig. 624). The bone is divided as described above for linear osteotomy.

Technique of Cuneiform Osteotomy

In cuneiform osteotomy a tourniquet is advisable. An incision 6 to 8 cm. long is made to the bone. When possible, the periosteum is reflected.

A wedge-shaped portion of bone is removed with a chisel (Fig. 624). The width of the wedge must depend upon the bone correction desired. The wedge may extend entirely through the bone, or the opposite cortex may be fractured by manipulation. The wounds in the periosteum, soft parts and skin are closed with fine chromic catgut or silk.

As after-treatment, the extremity is placed in a plaster cast. After three weeks the cast is changed, at which time further corrective manipulation may be made when necessary. After six to eight weeks union is usually sufficiently well advanced to permit the use of a brace.

OPERATIONS FOR BENIGN BONE TUMORS

OSTEOCHONDROMA AND OSTEOMA

Tumors of this type are frequently called exostoses. They are usually congenital in origin and occur near the ends of long bones. True osteomas usually occur in the frontal bone sinuses or jaw. They do not become malignant. Osteochondromas may undergo malignant changes and grow rapidly. Complete excision is usually indicated, although small growths which are symptomless may be left alone. When multiple, the growths producing symptoms may be excised.

OSTEOTOMY FOR BONE DEFORMITIES

Osteotomy is frequently indicated for the correction of such deformities as bowlegs (genu varum), knock-knees (genu valgum), malunion of fractures, ankylosis of joints in faulty position, torsions, coxa vara, stabilization of the foot, and the lengthen-

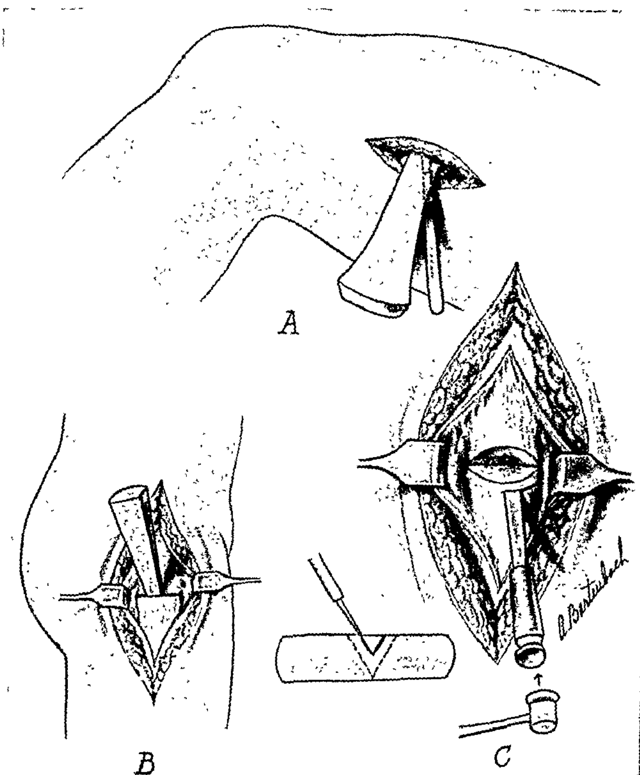


FIGURE 624. A, Technique of subcutaneous linear osteotomy. A short incision is made to the bone The osteotome is introduced with the knife as a guide To cut the bone, the osteotome is turned transversely when in contact with the bone B, Open method of osteotomy An incision is made, exposing the bone, and the bone is divided under vision C, Technique of open cuneiform osteotomy with a chisel. (Redrawn from Bickham Operative Surgery)

ing or shortening of bones. When contractures of soft structures are associated with bone deformity, tenotomy, fasciotomy, myotomy or capsulotomy may be a necessary part of the operation to permit correction.

Injury to nerves and blood vessels must be avoided. The danger of nonunion following osteotomy exists, but healing will usually result with proper after-treatment.

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As after-treatment, the extremity is placed in a plaster cast. After three weeks the cast is changed, at which time further corrective manipulation may be made when necessary. After six to eight weeks union is usually sufficiently well advanced to permit the use of a brace.

OPERATIONS FOR BENIGN BONE TUMORS

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Tumors of this type are frequently called exostoses. They are usually congenital in origin and occur near the ends of long bones. True osteomas usually occur in the frontal bone sinuses or jaw. They do not become malignant. Osteochondromas may undergo malignant changes and grow rapidly. Complete excision is usually indicated, although small growths which are symptomless may be left alone. When multiple, the growths producing symptoms may be excised.

Technique of Operation

Through an incision over the tumor the growth is freely exposed down to its base. Important structures are identified and protected. With a chisel, the entire tumor is removed, including a layer of the immediately adjacent cortex. The wound is closed without drainage.

CHONDROMA

This type of tumor is benign, although local recurrences after excision are not uncommon. *They are most commonly found centrally located in the small bones of the hands and feet.* They should be removed by *operation when causing symptoms, since they are not radiosensitive.*

Technique of Operation

The bone is exposed through a short incision in a position to best protect the tendons and nerves. The shell of bone is opened, and the tumor is thoroughly removed with a curet followed by cauterization with 50 per cent zinc chloride. If a large bone is involved, it is safer to excise the entire tumor area, since recurrence is not uncommon.

BONE CYST

Benign bone cysts are usually in the long bones and are common in children. *Pathologic fractures are not infrequent and may first indicate the presence of a cyst.*

Technique of Operation

The bone is exposed, and a window is cut through the cyst wall. All bone chips are saved. The cyst cavity is thoroughly curetted, swabbed with carbolic acid followed by alcohol, and irrigated with physiologic sodium chloride solution. The bone chips are placed in the cyst cavity. If the bone shaft is largely destroyed by the cyst, bone grafts may be placed across the cyst cavity. Drainage is not used. Adequate splinting *is necessary to prevent fracture during the healing period.*

EPULIS

Technique of Excision

Local or gas anesthesia may be used Because of the location of tumors of the epulis type, it is usually advisable to extract a tooth so that the periosteal attachment may be completely removed The tumor is completely excised down to the alveolar process, and its attachment is cauterized. It may be advisable to excise a portion of the alveolar process with large tumors. Sutures are not usually necessary. Good oral hygiene is the after-treatment.

Results of operation are good if the tumor is completely removed. These *tumors* rarely, if ever, become malignant, but local recurrence is common if removal is incomplete.

GIANT CELL TUMOR

These tumors usually occur at the end of long bones in young adults. They often cross the epiphysial line and invade the joint. A giant cell tumor may be benign or malignant. To differentiate between a benign giant cell tumor and a sarcoma is often difficult.

Treatment with x-rays has been successful. There is danger in such treatment unless a biopsy has been studied. Operative treatment may be curettage, excision or, rarely, amputation. There is some difference of opinion concerning the relative value of x-ray and operation. Operative treatment with a careful histologic study of the tumor is probably safer.

Technique of Operation

Curettage. The tumor is approached through an incision placed where it will least damage the overlying tissues. The overlying bone is opened with a chisel. The area to be removed may be first outlined with multiple drill holes. The tumor is completely curetted out, and the cavity is swabbed with phenol followed by alcohol and irrigation with physiologic sodium chloride solution. The thermocautery may be used. The bone cavity is filled with bone chips. Bone grafts across the cavity may be used.

Resection. The bone is exposed, and the part containing the tumor is completely removed. When function is little affected by excision of such bones as the upper end of the fibula, lower end of the ulna, upper end of the radius, metatarsals or metacarpals, no further treatment is necessary. When function is disturbed to any important degree by excision, bone grafts should be used when possible. Bone grafts are successful in the upper extremity, but because of weight-bearing in the lower extremity, faulty healing and fracture are not infrequent. When the tumor has involved a joint, bone grafts are rarely suitable for functional restoration of the joint.

Prolonged splinting is often necessary after curettage and always necessary after excision of a section of bone including a tumor.

OPERATIONS FOR MALIGNANT TUMORS OF BONE

OSTEOGENIC SARCOMAS

There are several recognized types of osteogenic sarcoma. They have been called chondrosarcomas, sclerosing sarcomas, osteolytic sarcomas, osteoblastic sarcomas, periosteal sarcomas and chondroblastic sarcomas. Although the degree of malignancy varies somewhat with different types and in different ages of patients, they are all very malignant and should be treated as such. In many cases an accurate diagnosis can be made only by biopsy

The treatment is generally disappointing. X-ray may be used, although many of these tumors are radioresistant Local excision has proved successful in some of the less malignant types. Early amputation is believed by many to be the treatment of choice. A combination of x-ray therapy and surgery is recommended.

Technique of Operation

A biopsy is taken through a small incision over the tumor. The type of tumor and

degree of malignancy are estimated from a study of the biopsy, x-ray, and history of development.

If the tumor is considered highly malignant, an amputation (if an extremity) is done well above the growth (see chapter on Amputation for technique). *If the tumor* is malignant, but slow growing, a local excision is done.

EWING'S SARCOMA

Ewing's sarcoma, or endothelial myeloma, usually involves the shafts of long bones in the first two decades of life. It is very malignant. It is best treated by thorough irradiation followed by excision or amputation.

ASPIRATION OF JOINTS

Aspiration of joints is indicated to remove blood or serous effusion or as a diagnostic measure to determine the presence and characteristics of a purulent exudate.

Technique of Joint Aspiration

The skin at the site of aspiration is carefully prepared as for operation. If any anesthetic is needed, local infiltration of procaine is usually sufficient.

Wrist. A needle is inserted into the wrist joint from the dorsal surface between the extensor longus pollicis and extensor indicis tendons beyond the distal end of the radius. It may also be reached through the "anatomical snuff-box" immediately below the radial styloid process.

Elbow. The needle is introduced posteriorly into the joint between the olecranon and lateral condyle.

Shoulder. This joint may be entered either anteriorly directly over the joint at the inner border of the deltoid muscle or laterally just below the tip of the acromion process.

Ankle. To aspirate the ankle joint, the needle is inserted anteriorly between the lateral margin of the extensor digitorum tendons and the external malleolus or between the anterior tibial tendon and internal malleolus.

Knee. This joint is aspirated either lateral or medial to the patella.

Hip. The femoral artery is identified by palpation The head of the femur is located behind the midpoint of a line drawn from the anterior superior spine to the symphysis pubis. The artery can usually be felt 3 to 5 cm. medial to this point. The aspirating needle is introduced directly backward to the joint at a point about 5 cm. lateral to the artery.

ARTHROTOMY

Incision and drainage of a joint is indicated for pyogenic arthritis. Arthrotomy is also used for reduction of dislocations, various plastic and reconstruction operations, and for many surgical procedures within the joint, such as the removal of a semilunar cartilage and loose bodies.

Technique of Arthrotomy for Drainage

A general anesthetic is usually advisable. A spinal anesthetic may be used for operations upon the lower extremity.

Wrist. An incision 5 to 6 cm. long is made on the dorsum of the wrist through the dorsal carpal ligament between the tendons of the extensor pollicis longus and the extensor indicis propius. The tendon sheaths should not be opened. The wound is left open and drained down to the joint with petrolatum gauze. A cock-up splint is applied.

Elbow. The elbow joint may be opened posteriorly by an incision made either medial or lateral to the triceps tendon. The incision is made 7 to 8 cm. long, extending across the joint. Injury to the ulnar nerve on the medial side is carefully avoided.

A lateral incision may be made to expose the radiohumeral articulation. The radial nerve is avoided.

The joint is drained with petrolatum gauze placed to the joint capsule. A splint is applied holding the elbow at an angle of 90 degrees.

Shoulder. The shoulder joint may be approached through either an anterior or posterior incision. The anterior approach is usually preferable.

An anterior incision 7 to 8 cm. long is made directly over the head of the humerus to separate the margins of the deltoid and the pectoralis major muscles. For the posterior approach an incision of the same length is made through the posterior portion of the deltoid muscle. The joint capsule is opened along the line of incision.

The wound is left open, and the joint is drained with petrolatum gauze placed to the capsule. A splint or cast is applied holding the arm in abduction of about 135 degrees.

Ankle. The ankle joint may be drained through an incision 5 to 6 cm. long anterior to either malleolus. Medially, the incision approaches the joint between the tendon of the tibialis anticus and internal malleolus and laterally between the lateral border of the extensor digitorum tendons and the external malleolus. Posterior drainage through an incision made over the joint either medial or lateral to the tendo achillis is preferred by some surgeons. A combination of the anterior and posterior incisions may be advisable in severe infections.

The wound is left open and drained down to the joint capsule with petrolatum gauze. To avoid drop foot, the ankle is splinted with the foot at a right angle to the leg.

Knee. Anterior drainage of the knee joint is usually preferred. Henderson has advised posterior drainage when the posterior portion of the joint is distended. An incision 7 to 8 cm. long is made to the joint on each side of the patellar tendon. If the Henderson approach is to be used, the knee is held in flexion, and an incision is made over the lateral surface of the joint anterior to the biceps tendon and head of the fibula. The peroneal nerve is retracted out of danger with the biceps tendon. The wound is packed down to the joint with petrolatum gauze. The knee is splinted in extension.

Hip. The hip joint may be drained from either the anterior or posterior aspect.

For *anterior* drainage an incision 8 to 10 cm. long is made downward from just below the anterior superior spine along the outer border of the sartorius muscle, separating this muscle from the tensor fasciae femoris and the vastus lateralis muscle.

Separation of these structures will expose the joint capsule. The joint capsule is incised.

A *posterior* exposure is made by the method of Ober. The incision is made over and parallel with the neck of the femur, extending medially beyond the femoral head and laterally beyond the trochanter. The fibers of the gluteus maximus muscle are separated in the line of incision, exposing a layer of fat in which the sciatic nerve is located toward the median end of the incision. This nerve is retracted medially to avoid injury. Beneath the layer of fat, the obturator internus, quadratus femoris, gemelli and pyriformis muscles are found and divided parallel with the femoral neck, exposing the joint capsule. If necessary for good exposure, these muscles may be divided at their attachments to the trochanter. The joint capsule is freely incised.

Drainage is established down to the joint capsule by suturing with catgut one or more of the cigarette type of drains to the margin of the incised capsule. The wound is partially closed.

OPERATIONS FOR RECURRENT DISLOCATION OF PATELLA

Technique of Goldthwait (Fig. 625)

An incision about 10 cm. long is made downward from over the patella along the patellar tendon, curving over the internal tibial tuberosity. The patellar tendon is

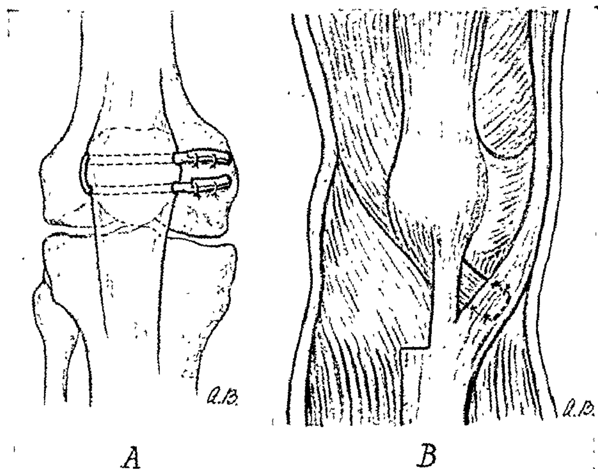


FIGURE 625 Techniques of operation for recurrent dislocation of the patella *A*, Method of Gallie and LeMesurier *B*, Method of Goldthwait.

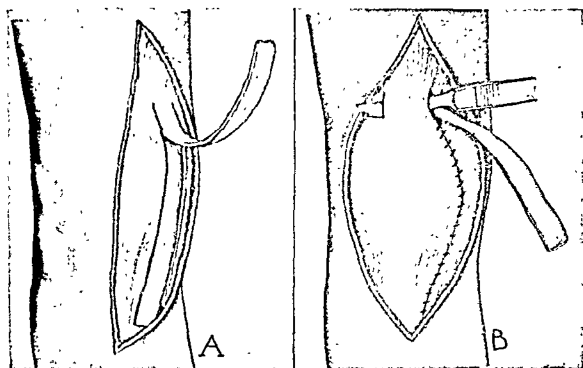


FIGURE 626. Technique of operation for recurrent dislocation of the patella. *A*, Dissection of strip of capsule and tendon, leaving proximal end attached *B*, Defect in capsule closed. Tunnel made through quadriceps extensor tendon. (Campbell: Operative Orthopedics, C. V. Mosby Company.)

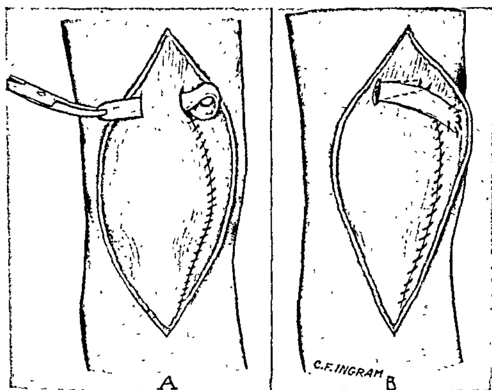


FIGURE 627. Technique of operation for recurrent dislocation of the patella (*continued*) *A*, Strip of capsule and tendon passed through quadriceps tendon from within outward *B*, Strip reflected medially and anchored to internal lateral ligament or joint capsule (Campbell Operative Orthopedics, C V. Mosby Company.)

split. The outer half is detached from the tibial tubercle, transplanted beneath the inner half and sutured to the periosteum of the inner anterior surface of the tibia.

Technique of Gallie and LeMesurier (Fig. 625)

A transverse incision is made across the patella. Two drill holes are made transversely through the patella and another through the condyle of the femur. A strip of fascia is passed through these holes and sutured with silk with the patella in proper position.

Technique of Campbell (Figs. 626, 627)

A longitudinal incision 15 cm. long is made medial to the patella. A strip of the joint capsule medial to the patella 10 cm. long and 2 cm. wide is freed, leaving the upper end attached. The wound in the capsule is closed with interrupted sutures of chromic catgut or silk. Through a tunnel made in the quadriceps extensor tendon above the patella, the pedicled flap of capsule is passed, reflected medially, and stitched to the joint capsule over the medial femoral condyle. The knee is immobilized in extension for six weeks, followed by active and passive motion.

OPEN REDUCTION FOR DISLOCATION OF THE THUMB

Dislocation of the first metacarpophalangeal joint may be impossible to reduce by the closed method because of the interposition of joint capsule or tendons.

Technique of Operation

An incision 6 cm. long is made over the radial side of the joint. The flexor tendons are retracted from between the joint surfaces while the dislocation is reduced by traction and manipulation. The thumb is splinted for ten days.

OPEN REDUCTION FOR ANTERIOR DISLOCATION OF THE SEMILUNAR BONE

Technique of Operation

An incision 8 cm. long is made in the anterior surface of the wrist parallel with the tendons. The median nerve is identified and retracted. The flexor tendons are separated from the median nerve and retracted. The dislocated semilunar bone is freed, and the fibrous tissue is removed from between the scaphoid and cuneiform bones. If possible, the bone is reduced and its capsule is sutured. If reduction is not possible or satisfactory, the bone is removed. The wrist is splinted in flexion if the bone has been reduced, or in dorsiflexion if the bone has been excised. Active and passive motion is begun in two weeks.

OPEN REDUCTION FOR DISLOCATION OF THE ACROMIOCLAVICULAR JOINT

Technique of Bunnell (Fig. 628)

An L-shaped incision is made with its apex 2 cm. anterolateral to the joint. The upper surfaces of the acromion, the outer end of the clavicle and the coracoid process with its ligaments are exposed.

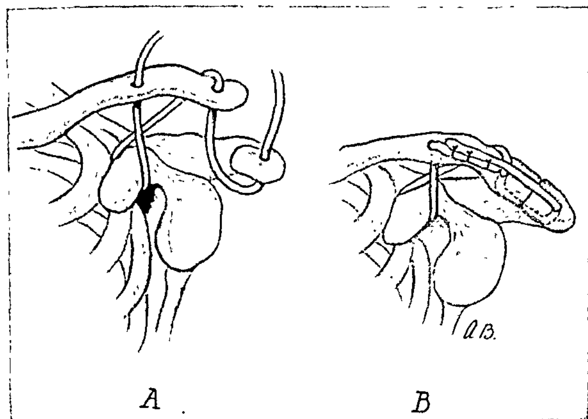


FIGURE 628. Technique of fascial graft for dislocation of the acromioclavicular joint. *A*, Fascial graft placed beneath the coracoid process and through holes bored in the clavicle and acromion process. *B*, The graft has been drawn taut, and the ends have been sutured together with silk. (Drawn from Bunnell: Surg., Gynec. & Obst.)

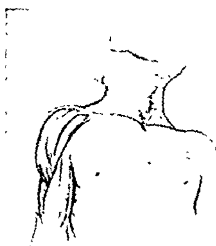
Holes 5 mm. in diameter are drilled through the acromion and the outer end of the clavicle, and through the clavicle at the outer end of the trapezoid ligament. The upper surfaces of the bones are denuded of periosteum in a line with the holes so that there will be bone contact with the fascial graft.

A strip of fascia lata is cut 25 cm. long and 1 cm. wide This is attached to a strong piece of catgut and passed down through the acromion, up through the end of the clavicle over the posterior surface of the clavicle, looped around the coracoid process, and then passed up through the second hole in the clavicle. A ligature of heavy chromic catgut is passed through the holes in the acromion and end of the clavicle and firmly tied to maintain reduction The ends of the fascial strip are then sutured together with chromic catgut or silk. The arm is immobilized in a Velpeau bandage for two weeks.

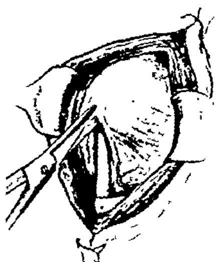
OPERATION FOR RECURRENT DISLOCATION OF THE SHOULDER

Technique of Nicola (Fig. 629)

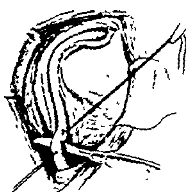
An incision about 12 cm. long is made from the outer end of the clavicle downward along the anterior border of the deltoid muscle. The fibers of the deltoid attached to the clavicle are divided, and the muscle is retracted outward. The pectoralis major muscle is retracted inward.



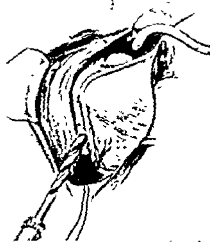
1. Anatomy showing incision in relation to underlying muscle.



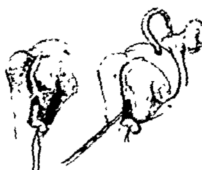
2. Exposure of tendon of long head of the biceps.



3. Tension sutures placed. Tendon cut below bicipital groove.



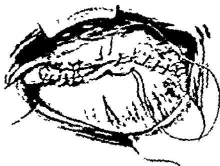
4. Oblique drill hole; bicipital groove to anatomical neck.



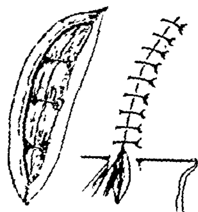
5. Method of threading proximal tendon end through hole.



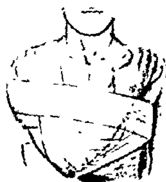
6. Technique of suturing cut ends of tendon with overlap.



7. Tendon sutured to periosteum. Bicipital groove closed.



8. Interrupted muscle sutures. Interrupted skin sutures.



9. Method of supporting dressing and arm; Velpeau bandage.

FIGURE 629 Nicola's technique of operation for recurrent dislocation of the shoulder (Courtesy of Johnson and Johnson, from Operative Procedure.)

The tendon of the long head of the biceps is exposed by dividing the transverse humeral ligament over the tendon. The joint capsule is opened in line with the tendon.

At a point about 2 to 3 cm. below the transverse humeral ligament, the biceps tendon is divided between silk stay sutures. A drill, about 8 to 10 mm. in diameter, is used to make a hole from the bicipital groove below the humeral ligament to the central articular surface of the humeral head. With a probe or wire used as a guide, the upper segment of the tendon is drawn through the drill hole and securely fixed to the lower portion of the severed tendon with fine silk sutures (see Bunnell method of tendon suture). The deltoid muscle is sutured in place along the clavicle, and the wound is closed in layers, using fine silk or catgut.

A Velpeau dressing may be used to immobilize the arm for two weeks, after which active and passive motion and physical therapy are begun.

Technique of Henderson (Figs. 630, 631, 632)

A curved incision with its base upward is made below the acromion process. After separating the fibers of the deltoid muscle in front and behind, a drill hole 8 to 10 mm. in diameter is made through the greater tuberosity. A similar drill hole is made transversely through the acromion process.

The peroneus longus tendon is exposed, and a section 25 cm. long, one-half of the tendon diameter, is removed and threaded through the prepared drill holes. This tendon segment is drawn taut, and the ends are securely sutured together with silk. The wounds are closed, and the arm is immobilized in a Velpeau dressing. Active motion and physical therapy are begun in two weeks.

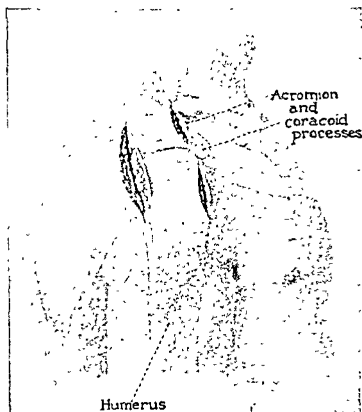


FIGURE 630. Technique of operation for habitual dislocation of the shoulder Incisions used in the shoulder. A curved incision with base upward may be substituted for the illustrated incisions (Henderson J.A M.A., Vol. 95.)

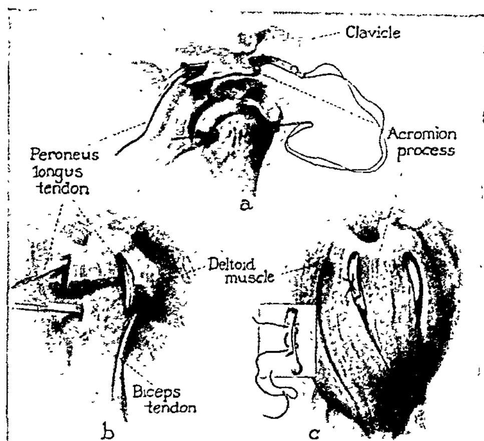


FIGURE 631. Technique of operation for habitual dislocation of the shoulder (*continued*). Drill holes have been made in the acromion process and humerus through which is passed a strip of the peroneus longus tendon. (Henderson. J.A.M.A., Vol. 95)

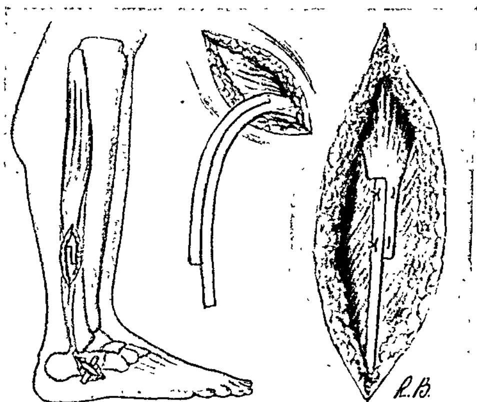


FIGURE 632 Technique of operation for habitual dislocation of the shoulder (*concluded*). Method of removing a piece of the peroneus longus tendon for repair of the shoulder. (Redrawn from Henderson: J.A.M.A., Vol. 95)

ARTHROTOMY FOR EXCISION OF SEMILUNAR CARTILAGE

General Considerations

Injuries of the semilunar cartilages or menisci of the knee joint are frequent and of great importance from the standpoint of disability. Injury to the medial cartilage occurs from five to seven times more frequently than injuries of the lateral cartilage. Although derangement of the semilunar cartilages may occur in an otherwise normal knee, a predisposing factor such as poor knee mechanics, degenerative or congenital abnormalities, unstable ligamentous support or inadequate musculature is often present. Many minor cartilage injuries will respond favorably to conservative management. Recurrence, however, is common, and after the first recurrent episode surgical removal of the damaged cartilage is indicated in most instances if the diagnosis is certain. Although partial removal of a damaged cartilage may suffice in certain

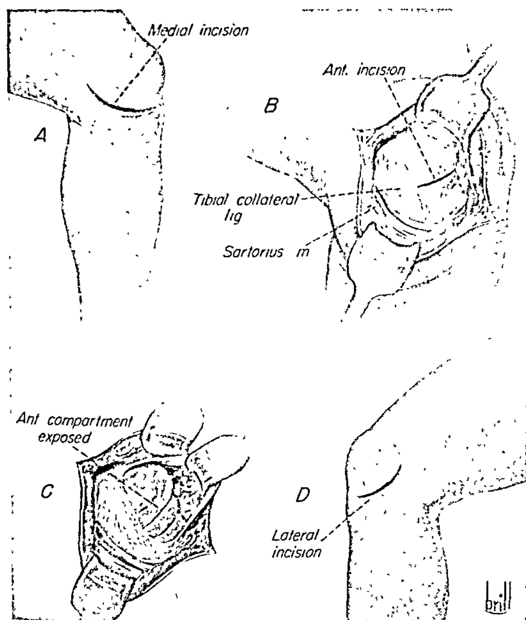


FIGURE 633 Excision of medial meniscus A, Modified Fisher incision B, The aponeurosis and joint capsule have been incised, and the synovial incision is outlined C, Exposure of the joint. D, Similar incision for removing lateral cartilages (A F DePalma Diseases of the Knee. Philadelphia, J. B. Lippincott Company.)

specified instances, removal of the entire semilunar cartilage is essential in the vast majority of cases.

Technique of Excising the Medial Meniscus (DePalma) (Figs. 633, 634)

General or spinal anesthesia is satisfactory. A tourniquet is used to ensure maximum exposure and visualization. The patient is placed in the supine position and the foot of the table dropped so that the knee is flexed to 90 degrees. A modified Fisher incision is made as follows: The incision is started just above the joint line immediately anterior to the tibial collateral ligament and extended downward and forward to the medial margin of the patellar tendon, terminating at a point 0.5 cm. below the superior border of the tibial condyle. Aponeurosis, capsule and synovium are incised in the same line as the skin incision. The infrapatellar fat pad is displaced laterally and the entire joint examined thoroughly. The anterior segment of the meniscus is mobilized by severing its peripheral attachments to the capsule, and the synovium and all its attachments to the tibia are divided under vision. The end of the meniscus is then grasped with a clamp and the tibial collateral ligament retracted inward and backward. The peripheral attachments of the meniscus to the inner surface of the tibial collateral ligament are then divided with a thin knife from below upward. By manipulating the leg, the joint space can be opened up to increase exposure, permitting

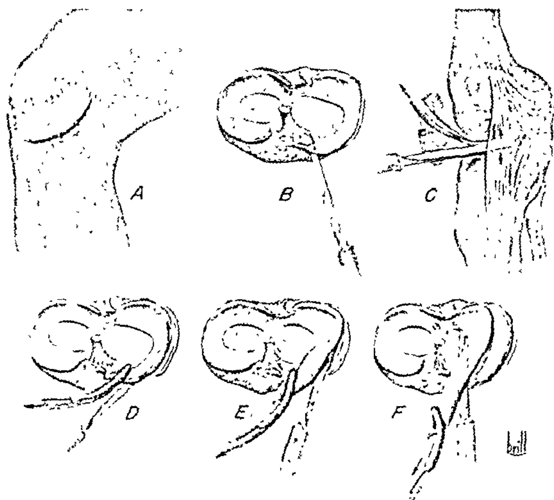


FIGURE 634 Excision of medial meniscus (*continued*) *A*, Modified Fisher incision *B*, *C*, *D*, *E* and *F*, Steps used to excise the medial meniscus (See text) (A F DePalma *Diseases of the Knee* Philadelphia, J B Lippincott Company)

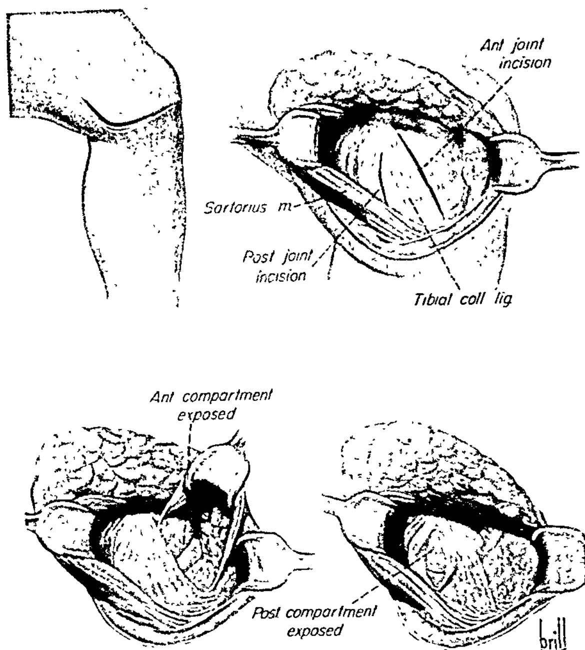


FIGURE 635. Excision of medial meniscus. Cave's incision, to be used when the necessity for entering both the anterior and the posterior compartments can be anticipated before the operation. (A. F DePalma· Diseases of the Knee. Philadelphia, J. B. Lippincott Company.)

division of the remaining peripheral tibial attachments of the meniscus. The meniscus can then be dislocated toward the center of the joint and the remaining posterior ccntral attachments divided under direct vision.

When exposure of the posterior portion of the meniscus is impossible or inade- ... may be necessary to make a second incision into the posterior compartment. ... the skin incision is extended posteriorly and slightly upward. An oblique ... is then made posterior to the collateral ligaments in the aponeurosis, ...um The meniscus can now be freed in its posterior portion under ... the two incisions into the joint space.

... inspected after removal of the cartilage and all loose fragments ...ce is flushed out with saline solution to ensure removal of any ... visualized. The foot of the table is then raised to complete

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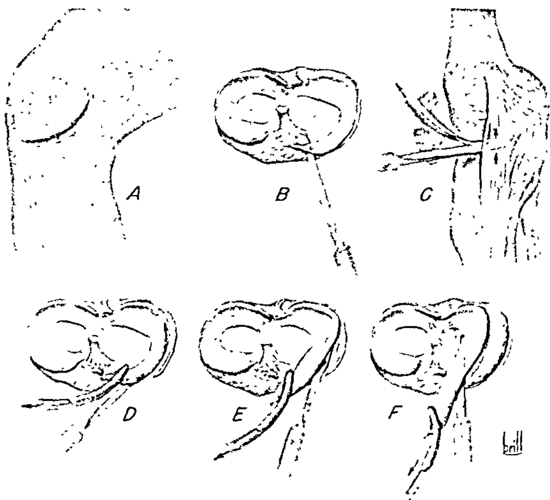


FIGURE 634 Excision of medial meniscus (*continued*). *A*, Modified Fisher incision. *B*, *C*, *D*, *E* and *F*, Steps used to excise the medial meniscus (See text) (A. F. DePalma. Diseases of the Knee. Philadelphia, J B Lippincott Company.)

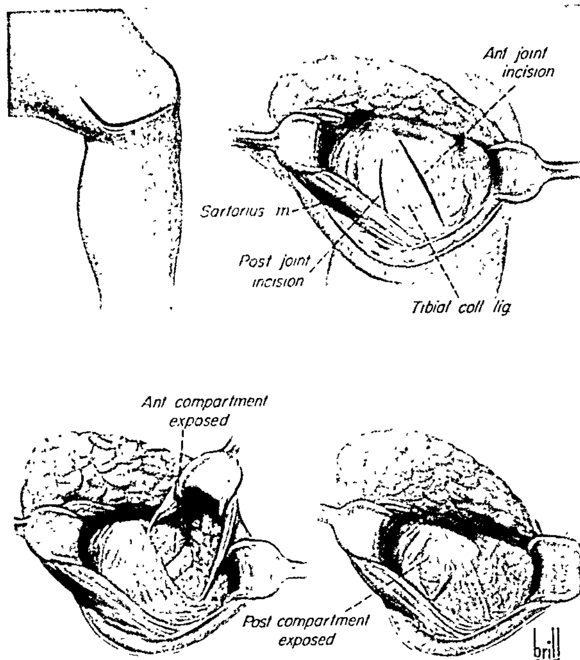


FIGURE 635. Excision of medial meniscus Cave's incision, to be used when the necessity for entering both the anterior and the posterior compartments can be anticipated before the operation. (A F DePalma: Diseases of the Knee Philadelphia, J B Lippincott Company)

division of the remaining peripheral tibial attachments of the meniscus. The meniscus can then be dislocated toward the center of the joint and the remaining posterior central attachments divided under direct vision.

When exposure of the posterior portion of the meniscus is impossible or inadequate, it may be necessary to make a second incision into the posterior compartment. In such cases the skin incision is extended posteriorly and slightly upward. An oblique curved incision is then made posterior to the collateral ligaments in the aponeurosis, capsule and synovium. The meniscus can now be freed in its posterior portion under direct vision, utilizing the two incisions into the joint space.

The joint is then inspected after removal of the cartilage and all loose fragments removed. The joint space is flushed out with saline solution to ensure removal of any additional fragments not visualized. The foot of the table is then raised to complete

extension of the leg in order to facilitate closure. The aponeurosis, capsule and synovium are approximated as one layer with interrupted sutures. Interrupted sutures are then used to close the subcutaneous tissue, and the skin is approximated with interrupted sutures.

When necessity for entering the posterior compartment can be antitipated, as for example when a lesion of the posterior segment is suspected or when removal of a cyst of the meniscus is to be done, Cave's incision (Fig. 635) may provide more ready access to the joint than does the modified Fisher incision described above.

Excision of the lateral semilunar cartilages may be done through similar incisions and exposure placed on the anterolateral aspect of the knee.

Postoperatively, an adequate bandage is applied to the knee, and an elastic bandage extending from the toe to the middle of the thigh is used to ensure snug compression. Quadriceps exercises are commenced on the second day and straight leg-raising exercises added on the third or fourth day. These exercises are gradually increased for approximately ten days, at which time weight-bearing may be resumed in most instances. A program of exercises designed to strengthen the muscles and ligaments in order to increase joint stability is important. Normal restoration of function should be complete in ten to twelve weeks.

OPEN REDUCTION FOR POSTERIOR DISLOCATION OF THE HIP

Technique of Operation (Fig. 636)

A Smith-Petersen incision is made. This incision begins along the anterior third of the iliac crest and extends to the anterior-superior spine and then curves downward along the lateral border of the sartorius muscle. The femoral fascia is incised along the lateral border of the sartorius, exposing the head of the rectus femoris. The muscle planes are separated, exposing the iliopsoas muscle. This muscle, with the sartorius, is retracted medially. The joint capsule is incised to expose the femoral head and neck.

The acetabulum is exposed, and any tissue present that might prevent reduction is removed. The head of the bone is freed by manipulation and severing of short muscles if necessary. The sciatic nerve, which may be in contact with the anterior surface of the head or neck, must be carefully protected. After freeing the head of the bone and clearing the acetabulum, reduction is usually accomplished by upward traction with the hip flexed to a right angle and adducted.

Associated fractures of the acetabulum are usually satisfactorily reduced by reducing the hip. If an acetabular fragment is large and is displaced after reduction of the hip, it may be pegged in place with autogenous bone pegs inserted through the fragment and directed upward from the joint surface.

The wound is closed by carefully suturing the joint capsule, muscle, fascia and skin. Drainage is not indicated.

As after-treatment, a Buck's extension is applied. If the acetabulum has been fractured or the joint is unstable, a spica cast is advisable. After three weeks the fixation is removed and crutches are allowed. Gradual weight-bearing is resumed after four to six weeks

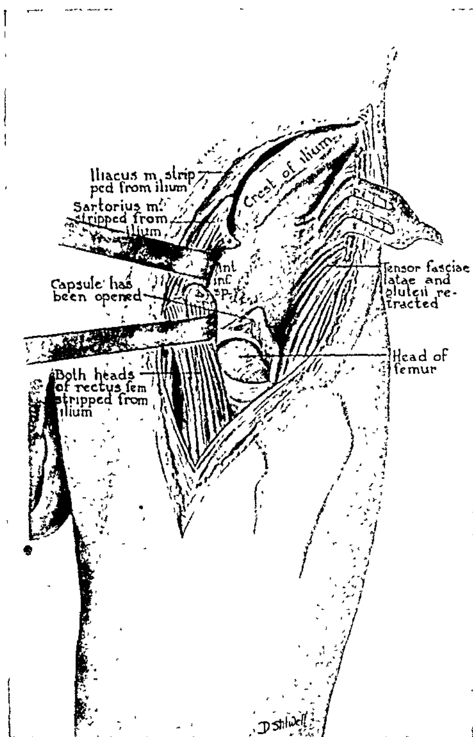


FIGURE 636. Smith-Petersen approach to the hip joint (Steindler Orthopedic Operations, 2nd ed. Courtesy of Charles C Thomas, publisher)

OPERATION FOR HAMMER TOE

Technique of Jones (Fig. 637)

An incision 2.5 cm. long is made over the joint parallel with the toe. The dorsal tendon is retracted, the joint capsule incised, and the ends of both bones are removed with rongeurs.

Although this position can be maintained by the application of a plantar splint, a Kirschner wire drilled longitudinally through the phalanges across the raw osseous surfaces serves as an excellent and efficient intramedullary nail. This is best done by

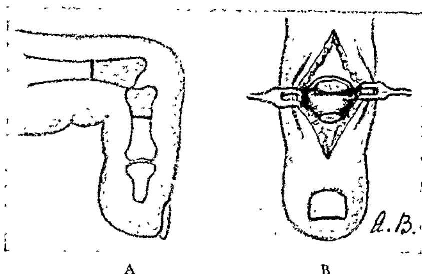


FIGURE 637. Robert Jones technique of operation for hammer toe. *A*, Shaded area shows portions of bone to be resected. *B*, After removal of sufficient bone to permit straightening of toe (Redrawn from Campbell's Operative Orthopedics, C. V. Mosby Company.)

first drilling the wire distally from the proximal raw osseous surface of the second phalanx out through the first phalanx through the end of the toe. The drill is then reversed on the wire, the raw osseous surfaces approximated, and the wire then drilled into the distal portion of the proximal phalanx to secure good approximation of the two raw osseous surfaces. The excess length of wire is then cut, leaving a short length protruding from the end of the toe. By bending the wire at a right angle, any possibility of the wire working its way inward is prevented. The joint capsule is then closed transversely and the skin approximated. Weight-bearing is permitted after two weeks, and the wire is removed three to four weeks after operation.

If the fifth toe is involved, fusion in this fashion is not attempted. Sufficient amounts of the joint and bone are removed to eliminate the deformity.

OPERATION FOR HALLUX VALGUS (BUNION)

General Considerations

Hallux valgus is a complicated deformity of the great toe and first metatarsal bone resulting in an inward bowing of the great toe with a concurrent lateral displacement and prominence of the head of the first metatarsal and metatarsal phalangeal joint. An underlying metatarsus primus varus, which is a widening of the space between the first and second metatarsal bones as a result of medial angulation of the first metatarsal bone at its articulation with the cuneiform bones, is the usual predisposing cause of this deformity. As a result of the bony abnormality there occurs a displacement of the tendons attached to the great toe with a resultant tendency to increase the underlying deformity. The medial prominence of the first metatarsal head, or bunion, represents for the most part a thickening of the bursa overlying this area, although there may be some increase in the actual bony structure as well.

Numerous operative procedures have been designed to correct this deformity. Plastic procedures such as the operation of McBride, limited principally to the soft structures, are effective when the hallux valgus deformity is moderate, particularly in younger persons The Keller and Mayo procedures, in which portions of bone are

excised to correct the deformity, are more suitable when the deformity is more pronounced, the latter procedure being useful in the elderly patient having other associated foot deformities.

Technique of McBride (Fig. 638)

A 2-inch incision is made along the lateral margin of the great toe and first metatarsal bone, beginning just proximal to the web space. The dissection is carried downward along the lateral aspect of the metatarsal phalangeal joint, taking care to protect the medial dorsal cutaneous nerve, which runs obliquely across the extensor tendon. The lateral sesamoid bone is then identified and enucleated. The conjoined tendon of the adductor hallucis and medial head of the flexor hallucis brevis is dissected from its insertion into the lateral aspect of the base of the proximal phalanx. Attention is now directed toward the medial side of the joint. If exposure through the first incision is inadequate, a second incision paralleling the first and located over the medial portion of the joint can be made. The thickened bursa and bony prominence of the metatarsal head are then removed. The medial joint capsule is then plicated. The conjoined adductor tendon is then shortened sufficiently to maintain proper alignment and reinserted into the lateral side of the neck of the first metatarsal with

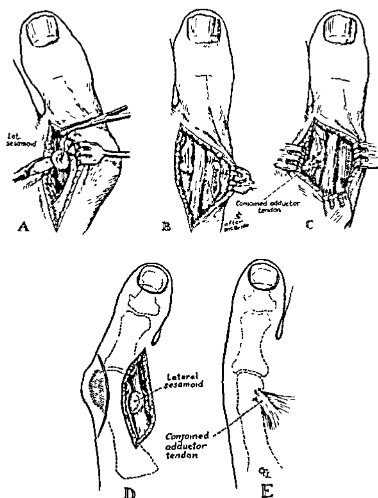


FIGURE 638. McBride procedure for hallux valgus *A*, Incision along the lateral margin of the first metatarsal phalangeal joint, and lateral sesamoid bone removed *B*, Prominent portion of metatarsal head excised and joint capsule plicated *C*, Reinsertion of conjoined adductor tendon into the metatarsal neck. *D* and *E*, Use of a second medial incision to afford better exposure of the metatarsal head. (Campbell: Operative Orthopedics. St Louis, C V. Mosby Company.)

two interrupted sutures. The wound is then flushed with saline solution and the incisions closed. A light plaster slipper or a spica of Elastoplast is applied to maintain transverse compression of the metatarsals and a slight overcorrection of the toe. Weight-bearing is resumed after approximately ten days, using a shoe with the toe cut out. Strapping to maintain slight overcorrection of the deformity for an additional two weeks to allow full healing of the tissues is advisable.

Technique of Keller (Fig. 639)

By removing the proximal portion of the phalanx, the great toe is shortened and the joint capsule and adductor tendons loosened to permit correction of the varus deformity. After operation there will be some loss of voluntary control of the toe.

A curved incision is made along the medial aspect of the metatarsal phalangeal joint with the convexity slightly toward the dorsum of the foot. The capsular ligament and periosteum at the base of the phalanx are incised and retracted to expose the joint surfaces. The joint is disarticulated and the proximal half to two thirds of the phalanx removed, using a Gigli saw or osteotome. Any increased exostoses of the metatarsal head are likewise removed with an osteotome. The periosteum and cap-

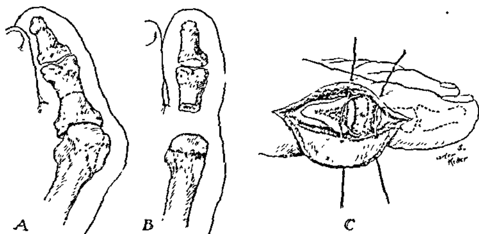


FIGURE 639 Keller operation for hallux valgus. *A*, Proximal portion of the first phalanx and excess portion of the metatarsal head to be excised are indicated by the dotted line. *B*, The result following excision of bone. *C*, Figure-of-eight suture to approximate the remains of periosteum, capsular ligament and soft tissue. (Campbell: Operative Orthopedics St. Louis, C V. Mosby Company.)

sular ligament and adjacent soft tissues are then brought together over the resected phalanx, using a figure-of-eight suture. The skin is closed with interrupted sutures. Longitudinal traction using a Kirschner wire through the terminal phalanx attached to a plaster cast outrigger arrangement is maintained for two weeks. After removal of traction a spica type of dressing is used, and weight-bearing is resumed gradually.

Technique of Mayo (Fig. 640)

A curved incision with dorsal convexity is made over the joint, and the skin is dissected downward, exposing the deformity. The bursa is not injured. A flap is made of the tissue overlying the joint, with its base at the proximal end of the phalanx. The head of the first metatarsal and bony excrescences are removed. The flap containing the bursa is turned inward between the metatarsal and phalanx and fixed in place

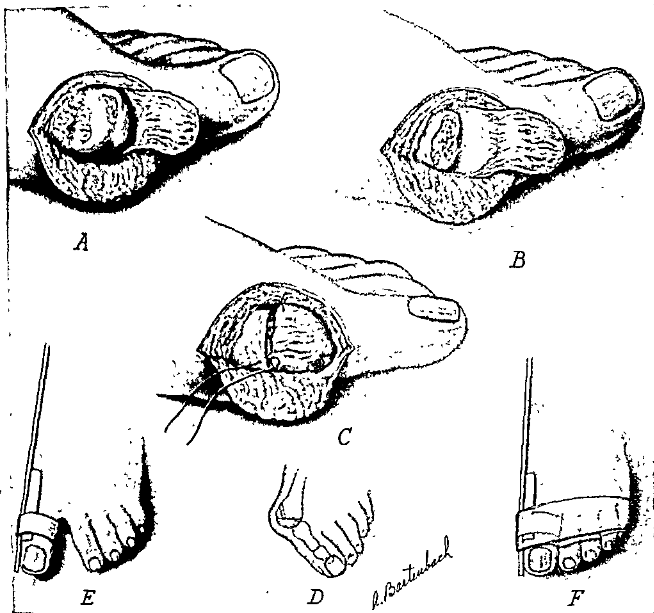


FIGURE 640. Mayo technique of operation for hallux valgus *A*, Skin flap turned down and fascial flap reflected toward toe. *B*, Head of metatarsal excised *C*, Fascial flap interposed between metatarsal and phalanx. *D*, Sketch to show bone that may be removed when necessary to reduce bony prominence. *E*, *F*, Kreuscher's method of postoperative splinting

with catgut sutures. To add stability to the new joint, the dorsal extensor tendon is drawn medially, and its sheath is fixed directly over the articulation. The skin wound is closed with interrupted sutures of fine catgut or silk.

Success depends much upon after-treatment. The great toe is splinted in slight abduction. After two weeks active and passive motion is begun. An orthopedic shoe is used. A splint is worn at night for several months.

NEUROMA OF PLANTAR NERVE (MORTON'S TOE)

Morton's toe, or metatarsalgia, is caused by a neuroma of the lateral branch of the medial plantar nerve situated between the third and fourth toes at the level of the metatarsal heads. Treatment consists in operative removal of the neuroma.

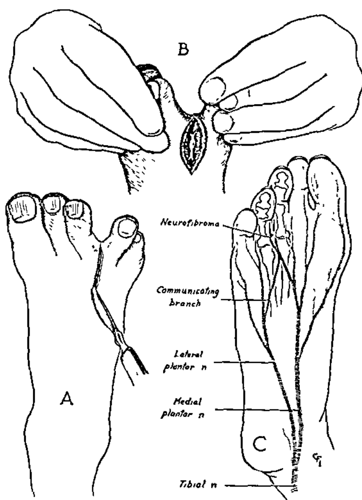


FIGURE 641. McElvenny technique for neuroma of plantar nerve. *A*, Site of incision. *B*, Exposure of neuroma. *C*, Anatomy of plantar nerve. (Campbell· Operative Orthopedics St. Louis, C. V. Mosby Company)

Technique of Operation (McElvenny) (Fig. 641)

An incision is made on the dorsum of the foot, beginning 1 inch proximal to the web between the third and fourth toes and extending to the junction of the web with the weight-bearing skin of the sole of the foot. The heads of the metatarsal bones are retracted and the transverse ligament excised. In most instances the neuroma bulges up into the wound after incision of the transverse ligament. The entire neuroma is excised. The wound is then closed. Weight-bearing is permitted as soon as the incision is healed, and special postoperative care is unnecessary.

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CHAPTER 16

The Nervous System

OPERATIONS UPON PERIPHERAL NERVES

General Considerations

Operations upon peripheral nerves are indicated chiefly for repair of defects resulting from injury or excision of tumors. Certain other operative procedures are used to relieve pain or to paralyze muscle and improve function.

Operations to restore nerve continuity (*neurorrhaphy*), to free nerves from scar tissue (*neurolysis*) and to free nerve funiculi (*endoneurolysis* or *hersage*) are standard procedures. For neurorrhaphy, the end-to-end union is the operation of choice. The use of nerve flaps, bridging or scaffolding material, and nerve im-

plantation are all of doubtful value. Nerve transplantation, nerve crossing a formation of artificial nerve branches have been reported successful.

After accidental division, nerves should be sutured promptly if the op wound can be properly cleansed and closed without tension. Koch warns that ne repair and incomplete closure of the wound are inconsistent with one another a will give unsatisfactory results. If in doubt about the cleanliness of the wound, it shou be closed without tension, and repair of the nerve should be postponed until af complete healing has taken place. Based upon their experiences with war woun Spurling and Woodhall conclude that early nerve suture (within three to six we after wounding) gives the best results. Zachary and Holmes state that early second nerve suture results in a higher percentage of recoveries than primary suture. Futu secondary nerve suture is made easier by fixing the severed nerve ends to prev retraction. After infection the secondary suture may usually be done with safety the end of three months after complete healing.

Injured nerves may be anatomically or physiologically interrupted. Davis sta that there is no way by which complete anatomical or physiological interruption c be differentiated. If there is doubt about complete or partial anatomical division c nerve, operation may be postponed for four to six months to await evidence of ne regeneration.

Nerve function following release of a nerve (neurolysis) may be noted in a sh time if there has been no degeneration of nerve fibers. After suture of a severed ner evidence of regeneration rarely appears in less than three or four months and m appear at any time within thirty months. Complete regeneration of a nerve is diffic to obtain after suture. In making an estimate of final results following secondary ne suture as reported from England, France and the United States, Stookey estima that there is complete regeneration in 50 to 60 per cent and total failure in 25 to 40 p cent. After neurolysis marked improvement has resulted in less than 40 per cent. many instances irreparable nerve damage has been done, and any improvement function of a part must depend upon training or other types of treatment.

General Operative Technique

When a portion of a nerve to be sutured is destroyed, tension may be minimiz by flexing the nearby joint or by rerouting the nerve to shorten the distance betwe the severed nerve ends. The change of position of various joints during nerve sutu may shorten the distance between nerve ends from 1 to 8 cm. If a nerve is dissect free for some distance, its natural elasticity will aid in suture.

Local *anesthesia* is the choice in many instances. Procaine, 0.5 per cent, w epinephrine is used. When general anesthesia is necessary, light ether or one of t gases may be used. Since nerve operations are likely to be of long duration, the patie should be comfortable on the operating table with the extremity to be operated up so placed that it may be moved freely.

Perfect hemostasis is necessary in nerve surgery. All bleeding vessels should ligated as the dissection progresses. A tourniquet may be used if desired. Local an thesia combined with epinephrine is a help in maintaining a bloodless field. An a

cumulation of blood about a nerve following completion of an operation will increase the production of scar tissue and impair function.

The *instruments* usually available in an operating room generally are suitable. Fine forceps are advised for holding the nerve sheath during suture. A small electrode for testing nerve function should be available. For shaping nerve ends, a new safety razor blade is valuable. For nerve suture, very fine black silk is used. Black silk separated into three strands and waxed as recommended by Stookey is satisfactory. Very fine curved or straight round needles are advised.

Wide exposure beyond the scar is necessary for nerve operations. Superficial scars are excised. The nerve is first exposed in normal tissue above and below the site of injury. Great care is exercised not to injure nerve branches. This necessitates a careful study of the anatomy of the region before dissection is begun.

Infection is probably the most common cause of complete failure of nerve suture. Thorough preoperative local preparation of the skin and scar is essential. The open wound margins must be protected by proper draping. Careful sharp dissection is used. The wound surfaces should be frequently bathed with salt solution to cleanse and prevent drying of tissues.

After operations upon nerves, *splinting* is necessary to produce rest and protect the nerve from injury. After two to three weeks gentle motion may be started. When joints are flexed to permit end-to-end suture, fixation for four to six weeks is advisable to permit nerve healing and beginning regeneration of neurofibrillae.

Technique of Primary Nerve Suture (Fig. 642)

Open wounds are carefully cleansed with soap and water followed by débridement and supplemented by frequent irrigations of physiologic sodium chloride solution (see Chapter 12). A tourniquet is used when possible. All structures are carefully identified before any sutures are placed. Frayed nerve ends are removed with a sharp, thin-bladed knife or razor blade. Scissors are never used. Axial rotation is avoided so that regenerating nerve fibers will follow the proper paths. A fine silk suture may be passed through the epineurium in the midline of the nerve when it is exposed to prevent torsion from its normal axis and to aid in approximation of the nerve ends. Fine silk interrupted sutures are placed through the epineurium to unite the nerve ends. The wound should be carefully closed without drainage.

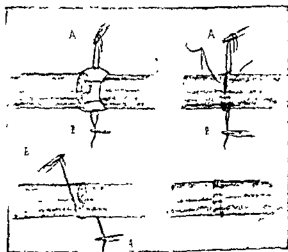


FIGURE 642 Technique of end-to-end nerve suture Two sutures are placed in the epineurium at equidistant points on the nerve. These sutures are used to steady the nerve for the insertion of the encircling epineural stitches. A sufficient number of epineural interrupted sutures are placed to ensure approximation of the nerve ends Very fine silk is used (Stookey: Nelson's Loose-Leaf Surgery, Vol. II)

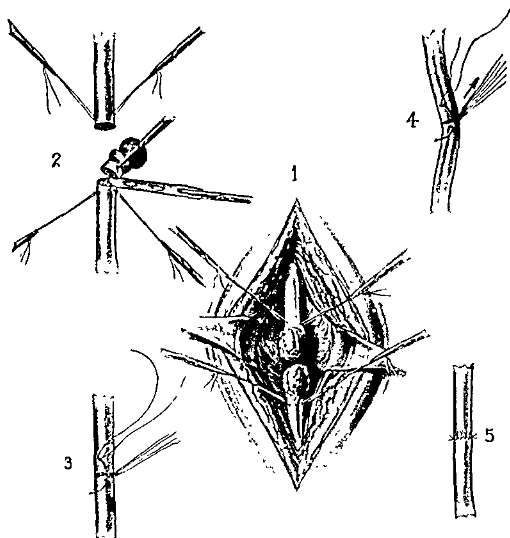


FIGURE 643. Neurolysis and end-to-end nerve suture. *1*, Ends of divided nerve after dissecting away adhesions The freed nerves are held by temporary sutures to prevent rotation and to facilitate suture. *2*, Successive slices are removed from the nerve ends until normal funiculi are seen. *3*, *4*, Ends of the nerve are carefully approximated with very fine interrupted silk sutures placed in the epineurium *5*, Nerve suture completed (Dean Lewis: Lewis' Surgery, Vol. III, W. F. Prior Co., Inc.)

Technique of Secondary Nerve Suture (Fig. 643)

The nerve ends are completely exposed. Since scarring is always present in the nerve ends, it is necessary to determine its extent. By palpation the consistency of the nerve will indicate where the first incision into the nerve is to be made. The approximate length of the scar and the defect to be bridged is estimated before the scarred nerve is cut away. Partial transverse incisions are then made into the nerve with a sharp thin scalpel or razor blade. The nerve is sectioned at short distances until normal nerve tissue is recognized by the discrete nerve bundles. If necessary, a magnifying glass may be used. When normal nerve tissue is reached by successive incisions into scarred nerve, two sutures are passed through the epineurium on each side of the nerve before it is completely severed. This step minimizes axial rotation of the nerve trunk.

The nerve ends are approximated by two primary sutures placed through the epineurium on opposite sides. These sutures are used for traction and to rotate the nerve as the final sutures are placed uniting the epineurium. During the suturing the nerve ends are irrigated with saline solution to avoid a layer of blood between the

sutured ends. Tension and angulation at the united ends are avoided. The nerve bed is carefully prepared. To reduce the possibility of future scar formation, the nerve should be placed in a fascial plane or between muscle bundles. The wound is closed without drainage.

Technique of Nerve Suture with Tantalum Wire (Fig. 644)

The nerve ends are freed and prepared for end-to-end suture. Tantalum wire, size 0.003 inch, is used because of its inert qualities, malleability and strength. To obtain accurate apposition of the nerve ends, a sling stitch is passed through the center of the nerve segments and tied. The perineurium is closed with interrupted stitches.

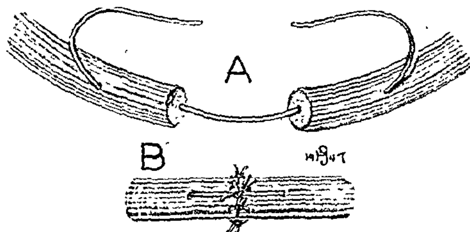


FIGURE 644 Technique of peripheral nerve suture. *A*, Sling stitch of size 0.003 inch tantalum wire passed through nerve ends *B*, Nerve suture completed showing interrupted sutures of fine tantalum wire in the perineurium and sling stitch tied. (Redrawn from Spurling. J. Neurosurgery, Vol I.)

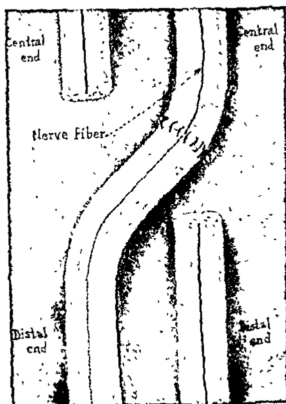


FIGURE 645 Complete nerve crossing. The distal end of one nerve is united to the proximal end of another nerve. End-to-end suture is made without tension. (Stookey. Nelson's Loose-Leaf Surgery, Vol. II)

Technique of Nerve Crossing (Fig. 645)

The steps in this operation differ little from those described above for end-to-end suture. A careful selection of the point of the nerve to be severed is necessary to avoid tension when sutured. To control the handling of the nerve and to prevent axial rotation, sutures are placed in the nerve sheath before it is severed.

In partial nerve crossing a portion of the nerve trunk is separated by splitting off a segment. This is done with a sharp knife by partially dividing the nerve transversely and separating it longitudinally between the funiculi.

Technique of Nerve Transplantation (Figs. 646 to 651)

This is technically a difficult operation. Transplantation is to be used as a last resort when all other methods have been abandoned. The percentage of failures is great. Stookey states that success depends in great measure upon the accuracy with which grafts are brought end to end, the correct placing of sutures, and just the proper

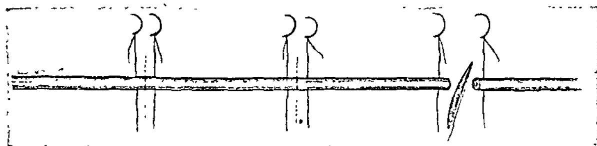


FIGURE 646. Technique of nerve transplantation The cutaneous nerve to be used is exposed, and the lengths of the grafts determined and marked by transfixing sutures. A sharp knife is used to cut the segments. (Stookey: Nelson's Loose-Leaf Surgery, Vol II)

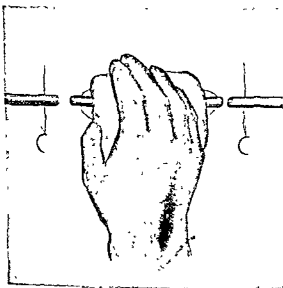


Fig 647.

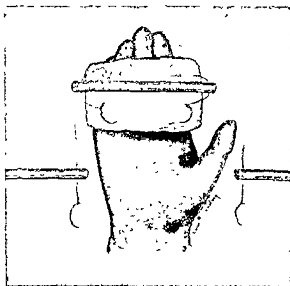


Fig 648

FIGURE 647. Technique of nerve transplantation (*continued*). Sutures are carefully placed to prevent twisting. Grafts are handled in moist cotton pads to prevent traumatism. (Stookey: Nelson's Loose-Leaf Surgery, Vol II)

FIGURE 648. Technique of nerve transplantation (*continued*) Nerve graft with sutures held on cotton pad ready to be transferred (Stookey Nelson's Loose-Leaf Surgery, Vol. II.)

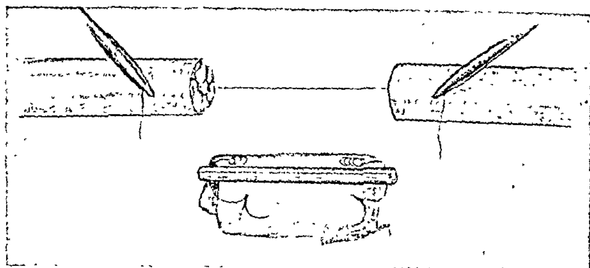


FIGURE 649. Technique of nerve transplantation (*continued*). Nerve ends are held in place by a temporary through-and-through suture held by forceps Nerve graft on cotton pad ready to be sutured into nerve defect. (Stookey: Nelson's Loose-Leaf Surgery, Vol. II.)

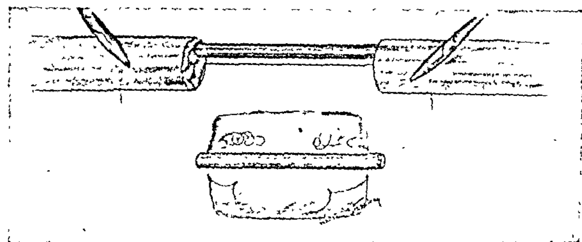


FIGURE 650. Technique of nerve transplantation (*continued*). One nerve graft sutured in place. End-to-end approximation must be accurate. (Stookey Nelson's Loose-Leaf Surgery, Vol. II.)

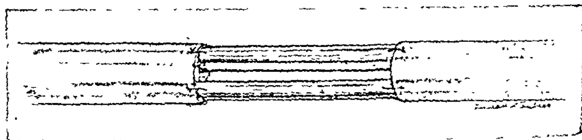


FIGURE 651 Technique of nerve transplantation (*concluded*). Four nerve segments have been sutured in place As much as possible of the cross-section area of the nerve should be covered with grafts (Stookey Nelson's Loose-Leaf Surgery, Vol. II.)

tension. A sufficient number of grafts should be used to cover the cross-section area of the central and distal stumps of the nerve to be repaired.

The nerve to be repaired is freed from all scar tissue and the nerve ends prepared as in end-to-end suture. The distance to be bridged is accurately measured. Fine stay sutures are placed through the nerve and fixed with hemostats to control handling and prevent axial rotation. Clamps must not be used on nerve tissue. A cutaneous nerve, such as the radialis or external saphenous in the leg, is usually used for grafts.

The nerve from which transplants are to be cut is laid bare, and sections to be removed are accurately measured. Fine waxed silk sutures are placed through the nerve at each end of the segment to be removed. The sutures are all passed in one direction to prevent axial rotation when the grafts are sutured in place. The nerve segments are covered with smooth moist cotton pads until suturing begins. The segments are handled as little as possible. During the suturing the nerve is kept moist by a stream of salt solution. The transplants are sutured into the nerve defect with great care, using very fine silk in the epineurium. When possible, the repaired nerve is placed in a new bed between muscles.

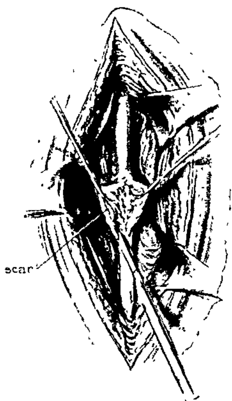


FIGURE 652. Neurolysis The scar is dissected away until the epineurium is exposed. Hemorrhage is carefully controlled The nerve is placed in a new bed free from scar tissue, *preferably in an intermuscular septum.* (Dean Lewis: Lewis' Surgery, Vol. III, W. F. Prior Co, Inc.)

Technique of Neurolysis (Fig. 652)

The nerve is exposed in normal tissue above and below the site of the lesion, carefully avoiding injury to nerve branches. All adhesions are separated about the nerve, and the scar is removed down to the epineurium. The epineurium is usually thickened and should be incised. When possible, the freed nerve is placed in a new bed between muscle bundles to avoid pressure and scar formation. Other methods which have been used to avoid re-formation of scar, such as surrounding the nerve with formalized arteries, free fascia or fat transplants, are of doubtful value. The new bed of the nerve must be free from any oozing of blood when the operation is completed. The wound is closed without drainage.

Technique of Endoneurolysis, or Hersage (Fig. 653)

Separation of the fibers of a scarred peripheral nerve may be necessary when there is thickening of the nerve sheath, exudate within the nerve, or general localized fibrosis. This method of treatment may vary from a simple longitudinal splitting of the epineural sheath to a complete dissociation of the fibers of a nerve.

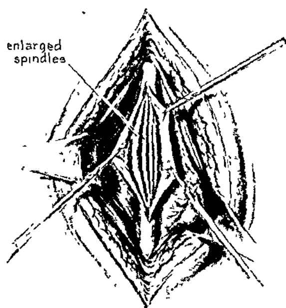


FIGURE 653. Endoneurolysis, or hersage. When the scar is endoneural, the epineurium is opened and funiculi are freed of scar tissue. (Dean Lewis: Lewis' Surgery, Vol III, W. F. Prior Co , Inc.)

Dean Lewis recommended longitudinal incision of the thickened epineurium as sufficient in most cases. From three to six longitudinal incisions may be required, depending upon the size of the nerve. This procedure is designed to overcome internal nerve compression. In selected cases dissociation of the fibers may be indicated.

NERVE CROSSING FOR FACIAL PARALYSIS

General Considerations

If the facial nerve is severed by accident or operation, immediate end-to-end suture is indicated as described above. If the nerve is injured by trauma or disease, a period of about six months should be allowed for regeneration. During this time the facial muscles should be treated by electrical stimulation and massage to prevent atrophy and deformity.

The facial nerve may be anastomosed to the spinal accessory (spinofacial) or hypoglossal nerve (hypoglossofacial). After section and anastomosis of the spinal accessory, motion of the facial muscles will be associated with shoulder movements. After severing the hypoglossal nerve there will be paralysis and atrophy of a part of the tongue. Most patients will consider these deformities of less importance than facial paralysis.

The result of anastomosis of the facial nerve is frequently unsatisfactory. Coleman states that when the facial muscles are disconnected from their central control, anastomosis will never result in recovery of the normal emotional expression. Motility may be restored to the paralyzed face by direct suture, nerve graft, or anastomosis in selected cases.

Technique of Spinofacial Anastomosis (Stookey) (Figs. 654, 655)

The incision begins over the mastoid and extends downward and forward a distance of about 8 cm., following the skin folds below the mandible. The deep fascia is

incised the full length of the skin incision. This will expose the lower portion of the parotid gland, which is retracted forward. The exit of the facial nerve is found just behind the styloid process. If difficulty is experienced in finding the nerve, the tip of the mastoid process, with its attached muscle, may be dissected off. The digastric muscle is identified and retracted downward and backward or severed when necessary. All small blood vessels encountered should be cut and promptly ligated to maintain a clear operative field.

The facial nerve is identified and lifted with a small hook or ligature passed about it for traction. It should be freed upward as far as possible. Before the nerve is cut across with a thin razor blade, two fine silk sutures are passed just distal to the point where the nerve is to be severed. The sutures, with their needles, are left attached to the nerve, which is protected with a moist cotton sponge.

The spinal accessory nerve is next exposed. It passes dorsal to the facial nerve at the level of the transverse process of the atlas, either behind or in front of the internal jugular vein. The spinal accessory nerve enters the sternocleidomastoid muscle about the junction of its upper and middle thirds.

As the next step, the hypoglossal and descendens hypoglossi nerves are exposed. The hypoglossal and vagus nerves lie in front of the internal jugular vein and transverse process of the atlas between the jugular and carotid. The carotid sheath is split

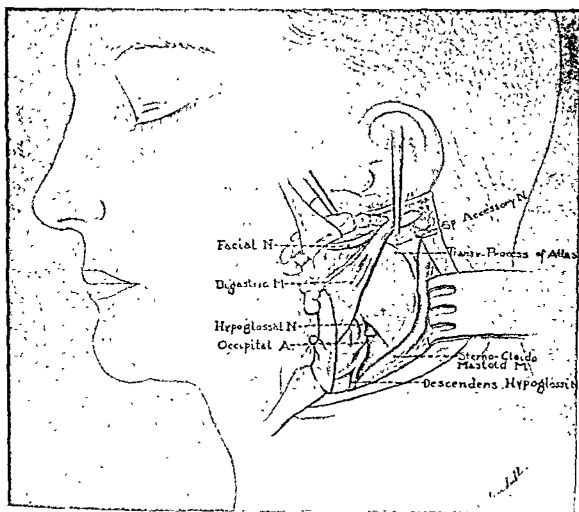


FIGURE 654 Technique of spinofacial nerve crossing. The facial and spinal accessory nerves are exposed preparatory to section and anastomosis (Stookey: Surgical and Mechanical Treatment of Peripheral Nerves)

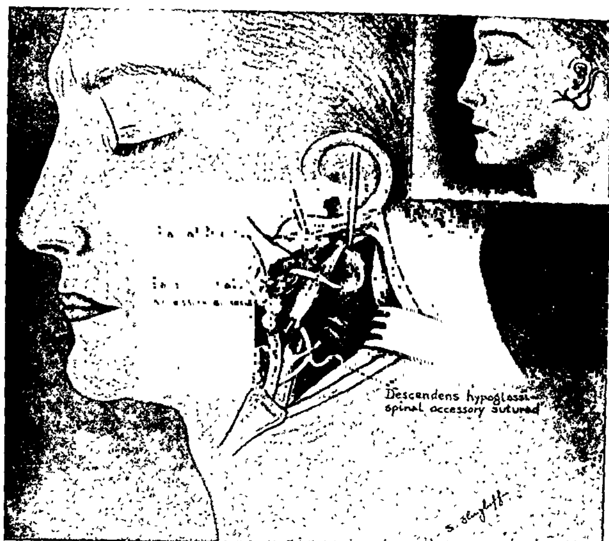


FIGURE 655. Technique of spinofacial nerve crossing (*continued*) The central end of the spinal accessory has been sutured to the distal end of the facial. The descendens hypoglossi has been divided, and the central end has been sutured to the distal end of the spinal accessory The insert shows the relation of the nerves after suture. (Stookey: Surgical and Mechanical Treatment of Peripheral Nerves)

to expose the hypoglossal nerve. The descendens hypoglossi lies along the outer border of the hypoglossal. The descendens hypoglossi is dissected free and cut as low as possible and protected with a cotton pad.

A distal point on the exposed spinal accessory nerve is selected for section which will permit suture to the facial nerve without tension. The sutures already placed in the severed facial nerve are passed through the spinal accessory nerve at a point just proximal to the point where it is to be divided. The spinal accessory nerve is then cut, and the proximal end is sutured to the distal end of the facial with the sutures already placed. The central end of the spinal accessory is passed over the lower border of the digastric muscle. The nerve ends must be sutured in accurate apposition without tension, angulation or torsion.

The proximal end of the descendens hypoglossi is sutured to the distal end of the spinal accessory nerve The wound is closed without drainage. It is advisable to immobilize the neck for two weeks with a plaster or Thomas collar.

Technique of Hypoglossofacial Anastomosis (Stookey) (Fig. 656)

The facial, hypoglossal and descendens hypoglossi nerves are exposed as described in the preceding section on spinofacial anastomosis. The vagus lies posterior to the

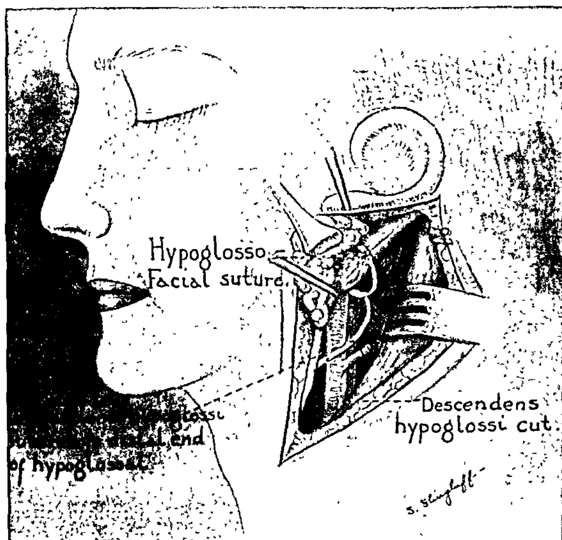


FIGURE 656. Technique of hypoglossofacial nerve crossing. The central end of the hypoglossal nerve is sutured to the distal end of the facial. The central end of the descendens hypoglossi has been sutured to the distal end of the hypoglossal. (Stookey: Surgical and Mechanical Treatment of Peripheral Nerves.)

hypoglossal and behind the carotid. The hypoglossal nerves curve slightly forward across the internal and external carotid arteries. The hypoglossal and descendens hypoglossi are exposed downward, the latter nearly to its union with the descendens cervicis. The two nerves are carefully separated and freed as high as possible to prevent angulation when sutured.

Four fine silk sutures are passed through the hypoglossal, two proximal and two distal to the point where the nerve is to be sectioned. The nerve is cut, and the central end is carried over or under the digastric muscle and sutured to the end of the facial in the same manner as described for spinofacial suture. The descendens hypoglossi is cut, and the proximal end is sutured to the distal end of the hypoglossal.

FACIAL SPASM

General Considerations

Facial spasm may be unilateral or bilateral. It may be temporarily relieved by alcohol injection or nerve section. If the disease is bilateral, it is wise to inject the

nerves on both sides with procaine as a preliminary measure to test the patient's ability to drink after paralyzing the upper branches of both nerves. Coleman prefers section and immediate suture of nerve rather than alcohol injection. In severe cases hypoglossal facial anastomosis is preferable to effect a permanent cure of the spasm. If the disease is bilateral, the hypoglossal nerve should be used on one side and the spinal accessory nerve on the other.

Facial paralysis is, of course, produced by any of these operations. This should be carefully explained to the patient before operation. The paralysis will be relieved by regeneration after suture of the severed nerve and after anastomosing the facial with the hypoglossal or spinal accessory nerve.

The technique of this operation does not differ in essential details from hypoglossofacial and spinofacial anastomosis described above.

BRACHIAL PLEXUS PARALYSIS

General Considerations

The extent of brachial plexus damage following birth injury or other types of trauma is difficult to determine. The nerve roots may be torn from the spinal cord or ruptured within the interveterbral foramina. It may be difficult to determine the extent of the gross damage within the nerves when exposed at operation. However, exploration of birth palsies and other brachial plexus injuries is justified after sufficient time has elapsed to permit regeneration. Immediate operations are rarely advisable except in fresh wounds of the plexus. A waiting period of six months to determine the extent of nerve regeneration is advised in other types of palsy due to brachial plexus injury.

Perfect results following operation should not be expected. However, the results obtained indicate that operation is the treatment of choice in those cases in which recovery does not take place under conservative treatment.

To obtain the best results, careful preoperative and postoperative care is essential. A thorough study of the anatomy of the brachial plexus and surrounding structures should be made before attempting operation.

Technique of Operation (Taylor) (Fig. 657)

The incision extends from the junction of the sternocleidomastoid muscle with the clavicle upward and outward to the border of the trapezius. This incision is carried through the fascia and platysma to the fat cushion in front of the plexus. All bleeding vessels should be promptly controlled by clamp and ligature to avoid infiltration of the tissues with blood. The external jugular vein and transverse cervical vessels are cut and tied.

The deep cervical fascia lies just in front of the plexus. It is usually scarred and thickened and adherent to muscles and nerves. The fifth and sixth cervical roots are exposed near the outer edge of the scalenus muscle and a little below the level of the sixth cervical transverse process. Injury to the nerves at this point is recognized by the scarring. The fascia is cut parallel to the border of these nerves and dissected away. The dissection is extended upward and downward, and all thickened fascia and

cicatricial muscle is cut away. The suprascapular nerve must be preserved as it leaves the outer margin of the external trunk just above the clavicle. This nerve controls external rotation of the shoulder. To avoid nerve injury, all dissection should be made parallel with the nerve trunks.

The seventh and eighth cervical and first thoracic nerve roots are exposed and freed from scar tissue. In this dissection the subclavian artery is exposed. When the roots are visualized, the dissection is carried peripheralward both in front of and behind the plexus.

Damage to nerve trunks is determined by noting changes in form, size and color,

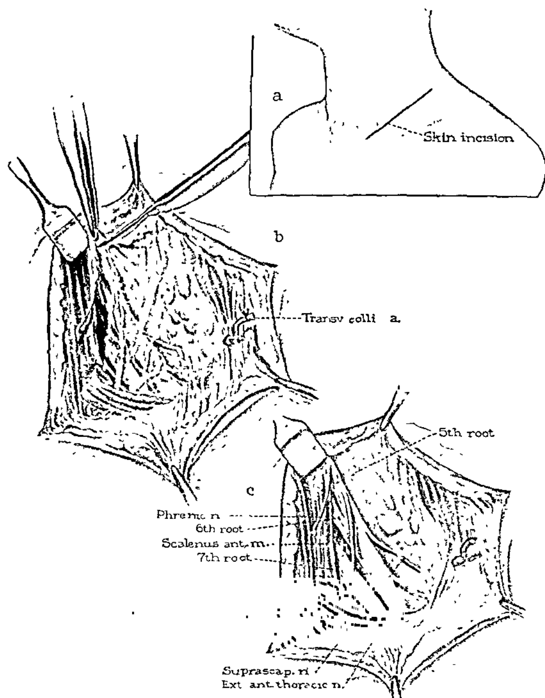


FIGURE 657 Operation for brachial birth palsy *a*, Line of skin and platysma incision. *b*, Superficial tissue dissected back, exposing deep fascia and scar tissue adherent to brachial plexus *c*, Normal plexus freed of scar tissue Additional exposure may be obtained by dividing the skin at a right angle to the original skin incision and sectioning the clavicle. (Taylor Lewis' Practice of Surgery, Vol. III, W. F. Prior Co., Inc)

by palpating the nerve consistency, and by electric current. If the nerve damage extends below the clavicle into the axilla, an incision is made at a right angle to and downward from the primary incision, and the clavicle is divided. If, after careful examination, resection and suture of damaged nerve trunks are necessary, the same technique as described previously for resection of a neuroma and neurorrhaphy is followed. Excessive tension, angulation and torsion are to be avoided when the nerve ends are united. To avoid tension, the shoulder and neck should be strongly approximated by an assistant and held in this position until the wound is closed and a fixation dressing applied.

Hemostasis must be complete. The platysma muscle and skin are closed with fine silk. To avoid injury to the plexus after operation, it is wise to fit a cast before operation which may be split and removed to be reapplied after operation. The brace holding the head and shoulder in approximation should be kept in place for three weeks. Postoperative protection and physical therapy are essential. A brace is worn for three months to protect paralyzed muscles until evidence of nerve regeneration is present. Treatment should be continued one to three years or even longer if there is hope of improvement.

CERVICAL RIB AND THE SCALENUS ANTICUS SYNDROME

General Considerations

In a discussion of the treatment of cervical rib Adson and Coffey conclude that tenotomy of the scalenus anticus is preferable to the more radical transcervical resection of the rib. The typical syndrome of cervical rib may occur when there is no cervical rib. This has been called the "scalenus anticus syndrome" (Naffziger).

The presence of a cervical rib found by chance is not an indication for operation. Operation is indicated if there is pain in the arm, deltoid region and neck, sensory or circulatory disturbances, or atrophy of the arm muscles directly attributable to the supernumerary rib.

Ochsner, Gage and DeBakey believe that the "scalenus anticus syndrome" is produced by contraction and spasm of the scalenus anticus muscle. They found supraclavicular tenderness over this muscle, and Gage has been able to relieve the symptoms of the "scalenus anticus syndrome" temporarily by injecting the muscle with procaine.

Good results may be expected by dividing or excising a portion of the scalenus anticus muscle. Complications which may occur during the operation are injury to the subclavian vessels, internal jugular vein, carotid artery, thyroid vessels, phrenic nerve, vagus nerve, brachial plexus, and pleura. Careful hemostasis is necessary to prevent a blood clot developing in the wound which may result in excessive scar formation.

Technique of Operation for Cervical Rib and the Scalenus Anticus Syndrome (Fig. 658)

General anesthesia is usually advisable, although local anesthesia is satisfactory in selected cases.

A transverse incision 6 cm. long is made in the supraclavicular fossa 2 cm. above and parallel with the clavicle, with its midportion over the posterior border of the sternocleidomastoid muscle. The incision is extended through the subcutaneous fascia and platysma muscle, exposing the sternocleidomastoid muscle, which is retracted medially. The scalenus anticus muscle is identified at its attachment to the first rib by palpation deep beneath the posterior border of the strenocleidomastoid. It is exposed by blunt dissection. It is frequently necessary to ligate the transverse cervical artery.

The phrenic nerve is identified passing obliquely across the scalenus anticus from without inward. The lower end of the scalenus anticus is carefully separated from the subclavian artery and brachial plexus with the finger. To protect these

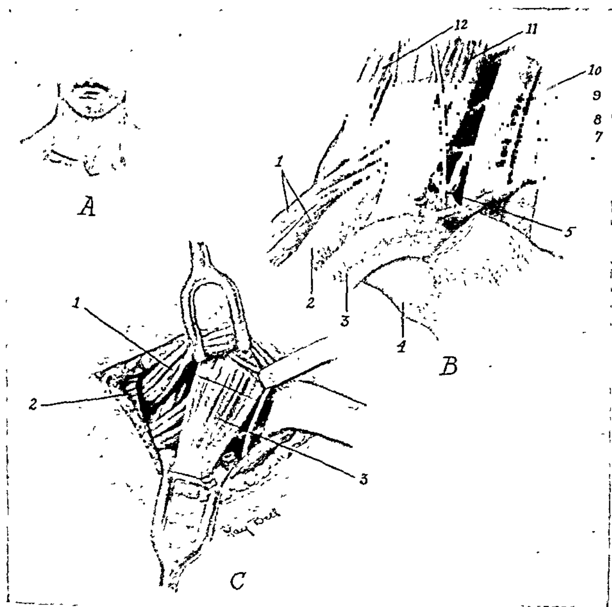


FIGURE 658 Technique of operation for "scalenus anticus syndrome." *A*, Skin incision made about 2 cm. above and parallel to the clavicle about 8 cm. long

B, Anatomical structures that may be exposed during operation. *1*, Brachial plexus; *2*, subclavian artery; *3*, subclavian vein; *4*, first rib, *5*, thyroid axis; *6*, inferior [illegible] rib; *9*, jugular vein; *10*, common carotid artery; *11*, scalenus anti [illegible]

C, Lines on scalenus anticus muscle indicate section to be [illegible] tysma muscle; *3*, portion of scalenus anticus to be removed.

structures, a flat instrument is passed between them and the muscle when the latter is divided. Section of the muscle is made near its insertion on the first rib. To avoid scarring across with return of the symptoms, a short section of the lower end of the muscle should be removed. Histologic study of the excised segment may show evidence of chronic inflammation and fibrosis. The subcutaneous tissues and platysma muscles and skin are closed with fine silk.

EXCISION OF PERIPHERAL NERVE TUMOR

General Considerations

Tumors of the peripheral nerves may be benign or malignant. Certain single *tumors may be excised. If the nerve fibers are directly involved, excision of the tumor* with a section of the nerve and end-to-end suture are indicated. Some of the benign neurofibromas and neuroblastomas may compress the nerve bundles and are subject to excision without severing the nerve. Such tumors may lie either within or without the nerve trunk.

Technique of Operation

If the tumor involves the nerve bundles, it is completely excised with the nerve tissue, and the nerve is united by end-to-end suture as described in another section.

When the nerve trunk is compressed by a tumor, the tumor is carefully dissected away without severing the nerve fibers. If the tumor is within the nerve and compressed nerve tissue completely surrounds the mass, the fibers are split longitudinally, and the tumor is carefully dissected out, preserving the nerve fibers. Such a tumor may, if benign, be removed with little damage to the nerve and with the expectation of a permanent cure.

FRACTURES OF THE SKULL

General Considerations

The indications for surgical treatment of skull fractures are (1) depressed fractures, (2) compound fractures, (3) fractures associated with middle meningeal arterial bleeding. Operations for acute intracranial pressure resulting from skull fracture are usually not indicated.

Depressed fractures of the skull may or may not be associated with laceration of the scalp. One or both tables may be depressed. Many minor depressions of the skull do not require operation. Operation is advised if there is evidence of intracranial hemorrhage or other brain injury. All compound injuries should be explored after careful treatment of the scalp wound.

When a bleeding middle meningeal artery is suspected, immediate operation is definitely indicated. The characteristic signs of extradural hemorrhage are dilatation of the pupil on the side of the hemorrhage, evidence of motor weakness on the side opposite the dilated pupil, and gradual onset of coma which may or may not be

preceded by a lucid interval. The mortality rate is high if treatment is not instituted early.

Dangers and Safeguards

The great danger of skull fracture is *injury to the brain* by either compression or laceration. Brain injury may be increased by injudicious operation. The next most important danger is *infection*, as a result of either compound injury or operation. Careful surgical technique and the judicious use of the antibiotics will do much to prevent and control infections. Early operation will reduce the danger of compression due to extradural or subdural hemorrhage.

Compound fractures of the skull are always contaminated and should receive the most careful and painstaking treatment to avoid meningitis, brain abscess and wound infection. The general principles outlined in the chapter on *Treatment of Fresh Wounds* apply in the care of scalp and skull injuries.

Foreign bodies or portions of bone carried into the brain substance should be removed through the fresh wound as early as possible, provided the operation can be done without too much injury to the brain tissue. Deeply embedded foreign bodies, such as bullets, had better be left for a future operation.

Shock not infrequently results from head injuries or associated injuries. Treatment of the head injury should usually be withheld during the shock state. Prompt control of bleeding may be necessary regardless of the state of shock. Treatment of a compound head injury should not be postponed longer than eight hours because of the increasing danger of infection. Many such injuries may be treated without anesthesia if the patient is unconscious or with local anesthesia if the injuries are not too extensive.

Drainage of compound wounds of the scalp, skull and brain is seldom indicated because of the danger of introducing infection. After the most careful cleansing and débridement possible, the wound is closed without drainage. If evidence of infection develops or if serum collects beneath the scalp, the wound may be carefully opened. When this is done, it is probably unwise to insert a drain.

Technique of Operation for Simple Depressed Fracture (Fig. 659)

Local anesthesia is usually satisfactory for this operation. A curved incision is made through the scalp 2 to 3 cm. beyond the margins of the depressed area. Bleeding is controlled by hemostats or Michel clips.

If the fragments of bone are loose, they may be removed with forceps. Frequently the fragments are firmly wedged in position and cannot be lifted without danger of increasing the trauma to the brain. When such a condition is found, an opening is made through the skull at the margin of the depression with a Hudson drill and burr. The depressed fragments are lifted with a periosteal elevator or cut away with a rongeur. Bleeding from the bone is controlled with a minimum quantity of bone wax.

The dura is carefully inspected for injury. If evidence of subdural bleeding is found, the dura should be opened and the brain surface carefully explored. Clots and crushed brain tissue should be removed with saline irrigation and gentle suction. Bleeding from the brain tissue may be controlled by Cushing clips or electrocoagulation.

Cotton sponges are used. Gauze is too coarse and rough. Defects in the brain

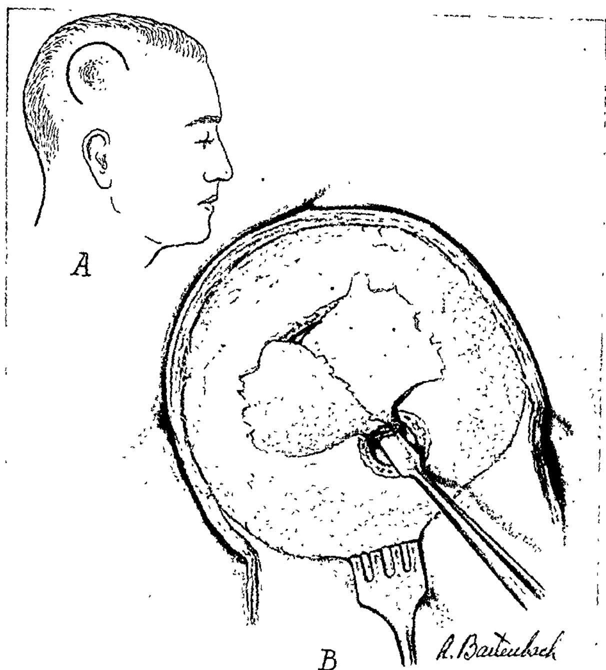


FIGURE 659 Technique of raising a depressed skull fracture *A*, Type of incision. *B*, Scalp flap deflected, exposing fracture. Opening in skull made by burr to admit elevator beneath depressed fragments of bone

should never be packed with gauze to control bleeding. Small bits of muscle or Gelfoam applied to a bleeding point may aid in the control of persistent oozing.

The dura is closed with silk sutures. If the dural defect is too large for closure, a small portion of fascia or galea may be used as a patch. The bone fragments should be replaced to close or partially close the skull defect. The scalp wound is closed with fine silk interrupted sutures in the galea and skin.

Drainage is usually unnecessary. If oozing is troublesome, a small rubber tissue drain may be placed through the skin to be removed in twenty-four hours.

Technique of Operation for Compound Fractures of the Skull (Figs. 660, 661)

A general anesthetic may be necessary if the lesion is extensive. The scalp is shaved over a wide area. If the wound in the scalp is large, the entire scalp should be

shaved. The wound is packed with gauze, and the surrounding scalp is thoroughly cleansed with soap and water. After this the pack is removed, and the wound is cleansed with soap and water and irrigated with physiologic sodium chloride solution. After careful débridement the wound and adjacent scalp are again washed with soap and water and irrigated. Particles of bone, hair or other foreign material are carefully removed with forceps. If the wound is extensive, Magnuson advises that it be enlarged with a tripod type of incision. If the brain is wounded with particles of bone driven into its substance, irrgation and suction are used to remove dirt, loose brain tissue and small fragments of bone. Large bone fragments are carefully removed with forceps.

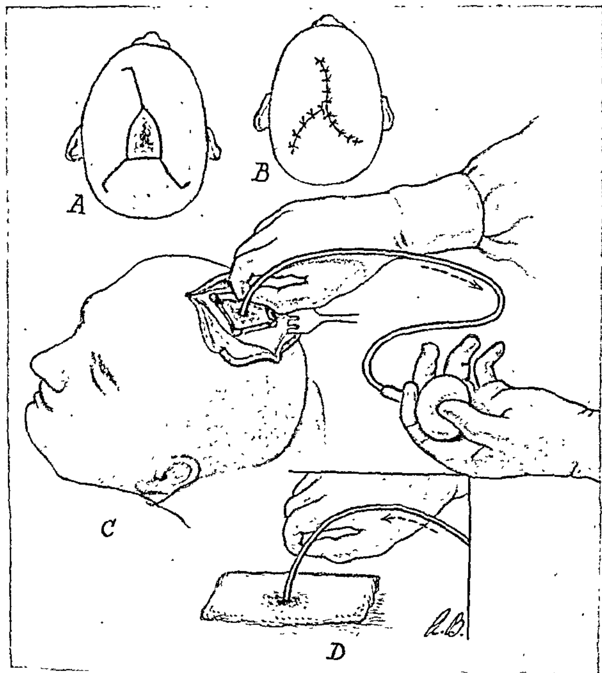


FIGURE 660. Technique of operation for compound fracture of skull. *A*, Diagram of a triangular incision about a lacerated scalp wound. *B*, Closure of incision after excision of scalp wound. *C*, Method of removing foreign material from a wound of the brain with gentle suction. *D*, Gentle irrigation of a brain wound through a soft rubber catheter. (Redrawn from Magnuson: Fractures, J. B. Lippincott Company.)

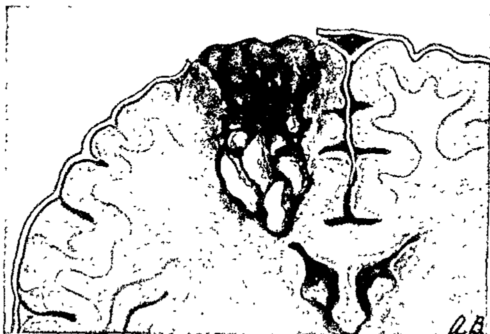


FIGURE 661. Diagrammatic sketch showing penetrating wound of the brain with bone fragments driven into the brain tissue. (Redrawn from Magnuson: Fractures, J. B Lippincott Company.)

Bleeding may be controlled by bits of muscle applied to oozing points and by Cushing clips or electrocoagulation. The opening in the dura should not be enlarged unless necessary. Antiseptics should not be used on the dura or in the brain substance. The opening in the dura is closed with fine silk sutures. Fascia or galea may be used as a patch when necessary. The scalp wound is closed in two layers, using fine interrupted silk sutures in the galea and skin. If drainage is used, the drain should extend to the dura and be removed in twenty-four hours.

Technique of Operation for Middle Meningeal Hemorrhage (Fig. 662)

The entire head should be shaved and both temporal regions prepared for operation. Occasionally it may be necessary to explore both sides when definite localizing signs are not present. Local anesthesia is usually satisfactory. A short incision is made at the upper margin of the temporal muscle in a vertical direction so that it may be extended downward toward the zygoma parallel with the muscle fibers. Through this small incision an opening is made in the skull with a burr. If evidence of a blood clot is found, the excision is extended downward and an area in the temporal bone is cut away with rongeurs. An opening 5 cm. in diameter is usually sufficient. Through this opening the bleeding vessel is located and ligated by passing a needle about it, clamped with a Cushing metal clip or coagulated with an electrosurgical current. If the bleeding vessel is in or near the foramen spinosum, it may readily be controlled by electrocoagulation. The clot is completely removed by forceps, cotton sponges soaked in saline solution, and by gentle suction. All small bleeding points must be controlled, leaving a dry field before the wound is closed. If bleeding from the dura beneath the bone margins is difficult to control, the dura near the bone may be sutured to the temporal muscle. Wax is used to control bone bleeding.

The muscle, fascia and skin are closed with fine silk. Drainage is not advised.

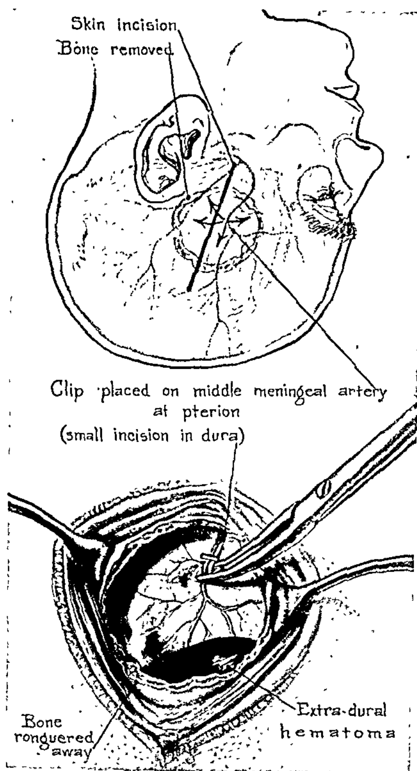


FIGURE 662. Method of exposing an extradural hemorrhage resulting from an injury to the middle meningeal artery (Dandy Lewis' Practice of Surgery, Vol XII, W. F. Prior Co , Inc.)

ARTERIAL ENCEPHALOGRAPHY

General Considerations

Roentgenograms taken after the injection of an opaque medium into the cerebral arterial tree are of great diagnostic aid in patients suspected of having intracranial disease. The obliteration or dislocation of the normal arterial tree or a cluster of new

vessels may indicate the presence of tumor or other space-occupying lesions. Alterations of the normal vascular pattern also may result from epidural or subdural hematoma and may be of great value in differentiating this lesion from other types of head injury. In addition, it may be possible to localize accurately the site of hematoma, thus simplifying the placement of burr holes for the evacuation of the clot. The localization of intracranial aneurysms by this method is of extreme value in planning for their surgical management. Injection of the dye into the common carotid artery can be done percutaneously, or in certain instances the common carotid or internal carotid artery can be isolated by means of a small incision and the arterial injection made under direct vision.

Technique of Percutaneous Injection

Depending upon the degree of alertness of the patient, Nembutal and Demerol are administered before the procedure. The patient is then tested for possible sensitivity to the substance to be injected. A 50 per cent aqueous solution of diatrizoate sodium (Hypaque) has been found to be most satisfactory. The patient is then placed in the recumbent position on an x-ray table and centered for an anterior posterior roentgenogram. The internal carotid artery on the side to be outlined is identified by palpation and local anesthesia obtained by the use of procaine. Direct arterial puncture is then made, using a 20-gauge short-beveled needle. Eight to 10 cc. of dye are injected rapidly and the film exposed as the last dye is being injected. In older aged patients 8 cc. of dye are usually used, while up to 10 cc. are used for younger patients. With the patient in the same position the equipment is shifted so as to take a lateral film on the side being studied, and a second injection and film are done. A third film taken approximately two to three seconds after injection in the lateral position may demonstrate the venous phase of filling and be of considerable diagnostic aid.

SUBDURAL HEMATOMA

General Considerations

In contrast to extradural or epidural hematoma, bleeding in the subdural space is usually caused by the tearing of a venous sinus or occasionally by laceration of a cortical vein and is rarely the result of arterial injury. Since the bleeding is of venous origin, the accumulation of clot proceeds in a comparatively slow fashion. Progression of symptoms may be due to the passage of fluid into the clot as a result of increased osmotic pressure following the breakdown of blood in the center of the clot. The clinical picture may be obscured by concomitant underlying brain damage. Arterial encephalography may be of extreme value in establishing the diagnosis and in determining the location of trephination for removal of the underlying clot. Approximately 50 per cent of subdural clots are bilateral.

Technique of Trephination for Subdural Hematoma (Fig. 663)

The entire head should be shaved. Local anesthesia is usually sufficient. If the clot has been localized by arteriography, the placement of trephine holes is simplified; otherwise a site approximately 3 cm. from the midline at the level of the coronal suture



FIGURE 663. Trephination for subdural hematoma. Site of burr holes for exploration The preliminary trephine holes may be connected by a curved incision to permit a classical osteoplastic bone flap if indicated.

is selected. A small transverse incision is made in the scalp. Self-retaining mastoid retractors are used to hold the scalp edges apart, and a burr hole is placed in the skull. The dura may be observed to be under tension and of a bluish discoloration because of the underlying clot. A stellate incision is made in the dura, after which the dark brownish material gushes forth. If the clot has been present for any length of time, there may be an organized outer membrane which must also be opened before the liquefied clot can be evacuated. The clot is further washed out by flushing with warm saline solution. When a large clot is present, the placement of a second burr hole on the same side 2 cm. above the posterior margin of the external ear to allow for through-and-through lavage may facilitate evacuation of the clot When no hematoma is encountered at the site of the first trephine, a second burr hole is placed as above for further exploration. In most cases bilateral trephination must be done because of the possibility of bilateral hematoma. After evacuation of the clot the incisions are closed in layers without drainage.

In the presence of a chronic subdural hematoma it may be necessary to turn down a classic osteoplastic bone flap to obtain sufficient exposure to permit complete removal of the hematoma.

FRACTURES OF THE SPINE

Indications for Operation

There is no immediate indication for operation upon the spine following injury when there are no signs or symptoms of spinal cord damage. Eliminating those cases of cord involvement in which operation is contraindicated because of poor general condition of the patient, those in which the compression may be relieved by manipulation, and those in which the cord has been completely transected, Mixter advises

laminectomy in the early cases when there are increasing neurological signs and stationary neurological signs with block. Operation is not advised when there are stationary neurological signs without block and when neurological signs are diminishing.

Positive evidence of complete division of the spinal cord is often not possible to obtain. Davis emphasizes the point that a complete anatomical lesion of the cord cannot be differentiated from a complete physiological section. If there is x-ray evidence of cord compression and block of the subarachnoid space is demonstrated by the Queckenstedt test, laminectomy is advisable.

If there is any justifiable evidence that an injury to the spinal cord may be benefited by operation, the patient should be given the benefit of operation. No one can determine the extent of cord damage without operation, and no one can predict the extent of recovery when the cord is not completely severed.

Laminectomy should not be done when a patient is in shock. A few hours of waiting for general improvement is justifiable. During the waiting period repeated neurological examinations should be made to obtain all evidence possible of the extent of the injury.

Technique of Laminectomy (Figs. 664 to 669)

Moving the patient to the operating room should be done with utmost care to avoid increasing cord injury. General anesthesia is usually used, although local anesthesia may be sufficient in selected cases.

An incision is made directly over the vertebrae of sufficient length to expose two spinous processes above and below the point of injury. The laminae of at least three vertebrae are exposed by carefully dissecting away the muscles from each side. Bleeding is carefully controlled by gauze pressure, electrocoagulation or fine ligatures before

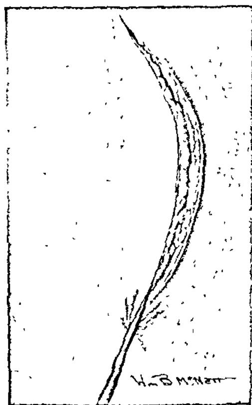


FIGURE 664 Technique of laminectomy Curved incision for skin flap. A median vertical incision may also be used. (Babcock· Textbook of Surgery)

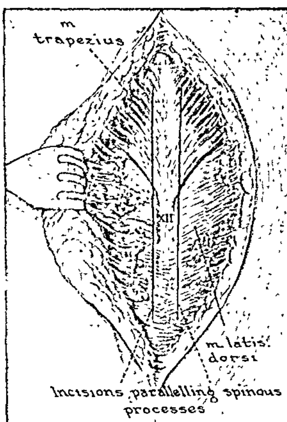


FIGURE 665. Technique of laminectomy (*continued*). The skin and fascia have been dissected up and retracted. The spinous processes are freed by lateral incisions. (Babcock: Textbook of Surgery.)

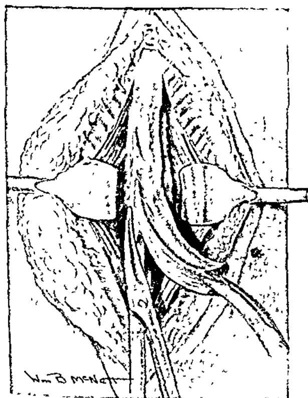


FIGURE 666 Technique of laminectomy (*continued*). The soft tissues about the spinous processes are cut with scissors, and the spinous processes are severed near the laminae with bone-cutting forceps. (Babcock Textbook of Surgery.)

the laminae are removed To avoid weakening the spine, the muscles should be damaged as little as possible. Exposure of the laminae is obtained with an automatic retractor.

Spinous processes of the laminae to be removed are clipped off with bone-cutting forceps. Beginning above or below the site of the injury, the laminae are cut away with rongeurs. This should be done with great care to avoid injuring t

cord. Instead of removing the spines completely, Mixter exposes the laminae on one side and undercuts the spines, leaving them attached to the intact interspinous ligaments to be retracted to one side with the muscles. The spines and interspinous ligaments are thus preserved to strengthen the spine later. Babcock also preserves the spinous processes attached to ligaments to be replaced when the wound is closed.

There is considerable bleeding during the operation. This may be somewhat minimized by raising the periosteum from the laminae to be retracted with the muscle. Small cotton sponges saturated with saline solution and bits of muscle aid in controlling oozing. Bone wax may be used to control bone bleeding. A suction tip is used to remove the blood.

The dura should be well exposed by controlling all bleeding and stripping away

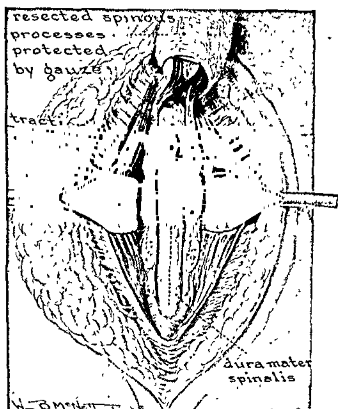


FIGURE 667. Technique of laminectomy (*continued*). Tissue containing spinous processes turned back and wrapped with gauze. Dura exposed and opened in the midline between traction sutures. (Babcock: Textbook of Surgery.)

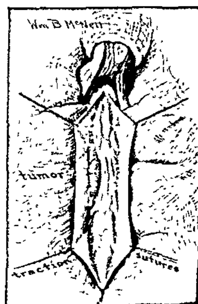


FIGURE 668. Technique of laminectomy (*continued*) The dura has been opened, exposing a small tumor (Babcock: Textbook of Surgery.)

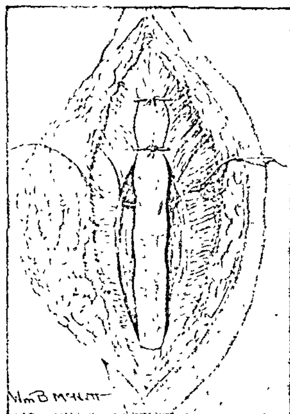


FIGURE 669. Technique of laminectomy (*concluded*). The dura has been closed with fine silk. The flap containing the spinous processes is being sutured into position so that it will not press upon the dura. (Babcock: Textbook of Surgery.)

the epidural fat before it is incised. A small opening is made in the dura which is enlarged along a carefully inserted grooved director. The margins of the incised dura are retracted by fine silk traction sutures.

The extent of injury to the cord is determined so far as possible. Any spicules of bone are removed. Blood clots are removed with forceps and gentle suction. In the neck a fracture-dislocation may be reduced in some cases before the wound is closed.

The dura is carefully sutured with fine silk. The muscle and fascia are closed with silk. Drainage is seldom necessary. A plaster shell is advised after the operation to prevent further damage to the cord. Skeletal traction may be necessary in neck fractures

HERNIATED NUCLEUS PULPOSUS

General Considerations

In 1934 Mixter and Barr described the anatomic and clinical findings resulting from rupture of the outer ring or annulus fibrosus of the intervertebral disk with resultant posterolateral protrusion of the nucleus pulposus Although considerable information had accumulated before this time, it remained for these authors to demonstrate clearly that spinal nerve root compression resulting from a lesion of the intervertebral disk was a common cause of severe sciatic pain. Since that time diagnosis of this condition has become fairly well clarified, and the management of these patients is fairly well standardized. In general, only those patients who have had repeated disabling attacks of sciatica with demonstrable neurologic changes indicating root compression are considered candidates for surgical correction. Other patients can usually be managed by conservative means. In those patients who have complained

predominantly of back pain with abnormal facets and evidence of an unstable back demonstrable by x-ray examination, removal of the degenerated disk cartilage combined with spinal fusion is indicated.

Although the history and physical findings may be diagnostic in many cases, considerable aid can be obtained by the use of contrast roentgenograms in which a contrast medium such as oxygen or one of the opaque materials is injected into the subarachnoid space and various views made to demonstrate protrusion of the nucleus pulposus into the spinal canal.

Technique of Operation (Fig. 670)

Either spinal or general anesthesia is suitable. If general anesthesia is to be used, an endotracheal tube is indicated, since the patient is placed in the face-down position. In certain instances local anesthesia may be used.

The patient is placed in the prone position, the face resting on a cerebellar head rest. A firm roll of sheets or blankets about 6 inches in diameter is placed under each side of the prone patient from shoulder to pelvis, thus leaving the abdomen free from compression and preventing engorgement of the predural venous plexus. The legs are then dropped by flexing the table.

A midline incision centered directly over the suspected disk and usually about 3 inches in length is made. A line between the iliac crest usually passes through the upper part of the spinous process of the fourth lumbar vertebra. The anterior posterior lumbosacral roentgenogram may be of value in accurate localization of the optimum site of the incision. The spinous ligament and periosteum are incised over the tips of the fourth and fifth lumbar and the first sacral spinous processes. Careful subperiosteal dissection can separate the soft tissue from the vertebra with a minimum of bleeding. The muscles are stripped from the spinous processes on the side of the lesion and retraction maintained by a self-retaining retractor.

The ligamentum flavum between the fifth lumbar and first sacral laminae is next removed. If additional exposure is then needed, a rim of the fifth lumbar and first sacral laminae to which the ligamentum flavum is attached may be removed with the Kerrison punch or a similar instrument. When the bulging herniated nucleus pulposus is demonstrated, the nerve root overlying this bulge is dissected carefully and retracted medially. The herniated mass may have disrupted the posterior longitudinal ligament and be free in the spinal canal; in other instances an incision must be made in the posterior longitudinal ligament and the loose material from the nucleus pulposus lifted out of its bed with forceps. The protruded nucleus may be in several pieces and may be attached to the annulus fibrosus. It is essential that all degenerated cartilage be removed, and this may be facilitated by introducing a pituitary rongeur through the opening in the annulus fibrosus to remove the degenerated nucleus.

Variations in the anatomical configuration are considerable from individual to individual. There is more space between the articular process and spinous process at the fifth lumbar interspace than at the fourth interspace.

Bleeding from a large venous plexus anterior and lateral to the dura may be troublesome, but usually can be controlled with electrocoagulation. After removal of the herniated nucleus the wound is closed in layers with nonabsorbable suture without drainage.

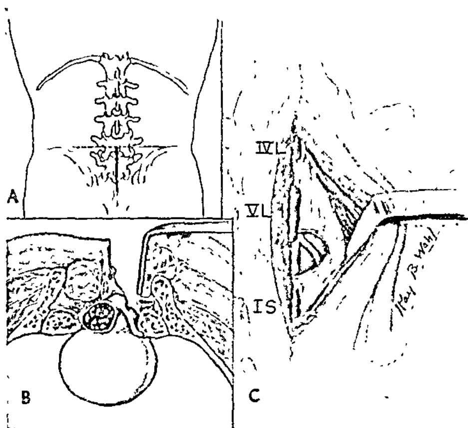


FIGURE 670. Technique of removal of herniated nucleus pulposus. *A*, Midline incision centered over the suspected disk *B*, The muscles are stripped from the spinous processes and retracted laterally, to be held by a self-retaining retractor. Sagittal view showing compression of nerve root by protruded nucleus *C*, The ligamentum flavum, between the fifth lumbar and first sacral laminae, has been removed, revealing compression of the fifth lumbar nerve root by the protruded nucleus pulposus

In most instances the patient may be out of bed on the third or fourth postoperative day and ambulatory by the seventh postoperative day. A gradual return to normal activity follows.

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CHAPTER 17

The Sympathetic Nervous System

General Considerations

Surgery of the sympathetic nervous system may still be considered in the developmental stage. Many operations have been devised and tried which are now abandoned as useless. Others are being done which have not yet proved their value. In a general review of surgery of the sympathetic system, White states that sympathectomy for epilepsy and spastic-

ity of muscle has been discarded. He also states that sympathectomy has been found to be of little or no value in the treatment of bronchial asthma, retinitis pigmentosa, atypical forms of facial neuralgia and rheumatoid arthritis.

Surgery of a system as intricate as the sympathetic system must be approached with caution. A careful study of the final results will undoubtedly change many of the present views concerning such therapy and determine what procedures are to become standard. The operations described in this chapter are presented because they have been widely used, but with the opinion that their true value in all instances has not been clearly established.

Before attempting any surgery of the sympathetic nervous system, it is advised that a careful study be made of the indications and results of such surgery. Excellent discussions of the subject may be found in the works of Gask and Ross, Kuntz, Adson, White, Smithwick, Peet and many others.

STELLATE GANGLION BLOCK

General Considerations

Since most of the sympathetic outflow to the head, neck and upper extremity passes through the inferior cervical or stellate ganglion, temporary blockage of this area by the injection of procaine or other local anesthetic agents may be a valuable diagnostic or therapeutic aid. Temporary blockage may be of value in determining the advisability of permanent blockage by stellate ganglionectomy or cervical dorsal sympathectomy. In addition, certain vasospastic conditions may be greatly benefited by interruption of the pain-spasm cycle. Since the sympathetic fibers to the heart and lungs also pass through the stellate ganglion, such conditions as status asthmaticus and angina pectoris may also receive temporary benefit from stellate ganglion blockage.

Technique of Stellate Ganglion Block (Anterior Approach)

The patient is placed in the dorsal recumbent position without a pillow with the arms at his side. The head is tilted backward for maximum extension. A point is located 3 cm lateral to the midline and 3.5 cm. above the clavicle. This point should lie over the transverse process of the seventh cervical vertebra and along the medial border of the sternocleidomastoid muscle. This point can be marked with an "x" or by raising a small intradermal wheal with a local anesthetic agent. This point can be further checked by instructing the patient to turn his head to the side opposite the one being blocked and palpating the sixth transverse process behind the lateral border of the sternocleidomastoid muscle This should be the most prominent transverse process. The transverse process of the seventh cervical vertebra previously identified should lie approximately 1.5 cm. distal to the transverse process of the sixth cervical vertebra identified in this fashion. With the head returned to the midline, the sternocleidomastoid muscle and the carotid sheath are retracted laterally by the fingers of the left hand, and a 2-inch 22-gauge needle is inserted through the previous wheal perpendicular to the skin in all planes until it reaches the transverse process of the seventh cervical vertebra. If the needle does not impinge on bone, or if parasthesias of

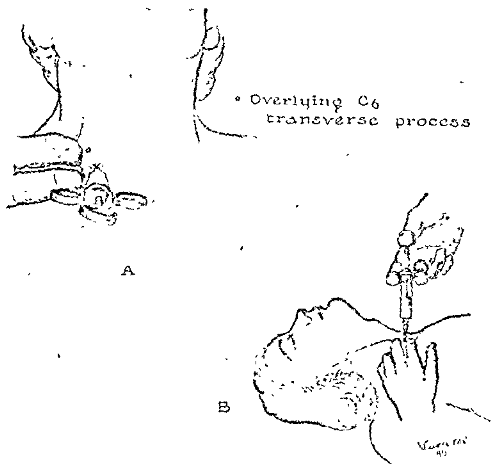


FIGURE 671. Stellate ganglion block. Anterior and lateral views to show the position of the syringe and needle to be directed at an angle of 90 degrees to the skin in all planes, with the sternocleidomastoid muscle and carotid sheath contents retracted laterally. (C. D. Moore. Regional Block. Springfield, Ill., Charles C Thomas.)

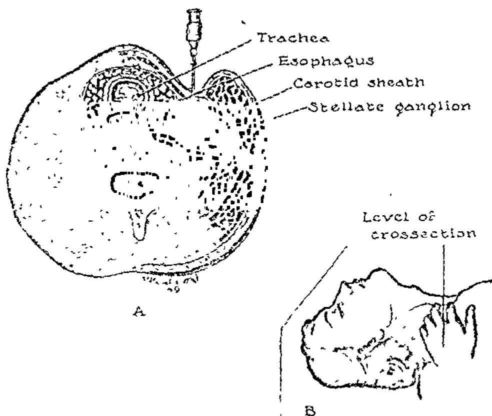


Fig. 672

the brachial plexus occur, the needle should be withdrawn slightly and redirected more medially or pointed caudally or cephalad until it impinges upon bone. The needle is then withdrawn slightly to free it from the muscle substance overlying the transverse process, and after a careful aspiration test 10 to 15 cc. of either lidocaine or procaine 2 per cent are injected slowly and the needle withdrawn.

Successful block will be indicated by injection of the conjunctiva, constriction of the pupil, increased temperature of the arm and face and anhydrosis of the face and arm, all on the affected side.

Bilateral stellate ganglion block should not be done at the same time because of the possibility of producing bilateral pneumothorax.

LUMBAR SYMPATHETIC BLOCK

General Considerations

Blocking the lumbar sympathetic ganglia with a local anesthetic agent to produce vasodilatation has been recommended by Leriche and Kunlin and by Ochsner and DeBakey for the treatment of thrombophlebitis in the lower extremities. It is assumed that vasomotor reflexes are initiated by the involved venous segment resulting in arterial spasm, venospasm and coagulation. This reflex is broken by blocking the sympathetic ganglia with local anesthesia. Reports of excellent results with this type of therapy have been made. The relief of pain is prompt, and fever and edema subside in a few days. Two or three injections may be required in some cases before pain is permanently relieved. By this method of treatment, convalescence is much shortened and patients are usually ready to leave the hospital within two weeks.

Vasospasm resulting from trauma or injury to the femoral vessels may also be relieved by paravertebral sympathetic block. Patients who have had arterial blockage due to thrombosis or embolus not amenable to operative removal may be markedly benefited by interruption of the sympathetic supply and resultant relief of vasospasm which often accompanies such insults.

Temporary blockage of the lumbar sympathetic chain may be of value in determing the advisability of producing permanent sympathetcomy by operative removal of the ganglia.

Technique of Injection of Lumbar Ganglia (Fig. 673)

The treatment is usually given with the patient in bed in the lateral position. The skin is anesthetized with 1 per cent procaine at points about 4 cm. from the midline over the transverse processes of the first, second, third and fourth lumbar vertebrae. A 20- or 22-gauge needle 8 to 10 cm. long is used. The needle is inserted down to the transverse process, usually a distance of 4 to 5 cm. The direction of the needle is

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FIGURE 672. Stellate ganglion block. *B*, Position of the patient's head, lying flat without a pillow and with the head tilted backward for maximum extension The index and middle fingers retract the sternocleidomastoid muscle and carotid sheath and contents laterally. *A*, Illustration of the retraction effect of the index and middle fingers to permit the needle to be directed to the transverse process of the seventh thoracic vertebra, which serves as a landmark for identification of the stellate ganglion. (C. D Moore. Regional Block. Springfield, Ill , Charles C Thomas.)

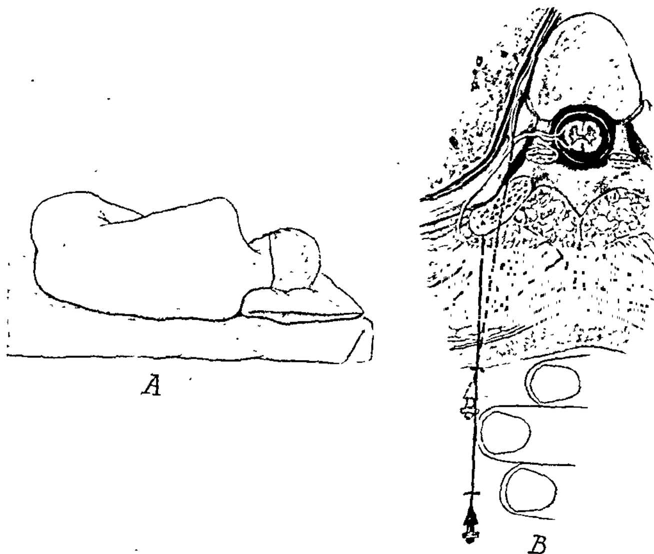


FIGURE 673. Lumbar sympathetic block A, Patient in lateral recumbent position B, Needle inserted vertically until transverse process is reached. Direction of needle changed slightly toward midline and further inserted approximately 2½ finger breadths beyond the transverse process until its point lies near the anterolateral surface of the body of the vertebra at the location of the sympathetic chain. Five cubic centimeters of 1 per cent procaine hydrochloride are injected anterior to the first, second, third and fourth lumbar transverse processes. (After Ochsner and DeBakey. Arch Surg.)

then changed to pass the transverse process above or below and pointed slightly toward the midline. It is further inserted about 4 cm. until it impinges upon the anterolateral surface of the body of the vertebra in the retroperitoneal space. The four needles are placed, and through each are injected 5 cc. of a 1 per cent procaine solution. As the needles are inserted, aspiration should always be made to avoid injection of solution into a blood vessel.

Within a few minutes after a satisfactory injection the extremity on the corresponding side will become warm and dry. Superficial veins may be visibly more prominent.

Temporary blockage of the sympathetic supply to the lower extremity over a period of several days can be obtained by passing a polyethylene tube through a needle cannula into the retroperitoneal paravertebral space. Periodic injections of a local

anesthetic solution can then be made, thus avoiding the necessity of reinserting the needle.

PERIARTERIAL SYMPATHECTOMY

Indications

This operation probably has limited therapeutic value, although good reports of its use have been recorded. It has been used for various disorders of circulation of the extremities such as senile and diabetic gangrene, intermittent claudication, causalgia, painful amputation stumps, trophic ulcers, thromboangiitis obliterans, scleroderma, Raynaud's disease, acrocyanosis and certain edemas.

Technique of Operation (Gask and Ross) (Fig. 674)

Local anesthesia may be used. An incision 8 to 10 cm. long is made over the artery (usually the femoral or brachial). The proximal portion of the artery is exposed. The sheath of the artery and its tunica adventitia are incised longitudinally for at least 5 cm. It is then peeled out of its outer coverings. This includes the sheath and tunica adventitia proper. If necessary, the sheath may be peeled off the veins accompanying the artery.

If a small stream of physiologic sodium chloride solution is allowed to trickle over the vessels, further strands attached to the arterial wall will become apparent by floating in the liquid. All tissue must be removed until the middle coat appears smooth. The denuded artery contracts to a small size, grows pale or white, and pulsation may cease beyond the area of operation. The contractions are an indication that the vessel has been adequately denuded. To ensure destruction of all nerve fibers, the artery is painted with 90 per cent alcohol and washed with saline to remove the excess. The wound is closed without drainage.

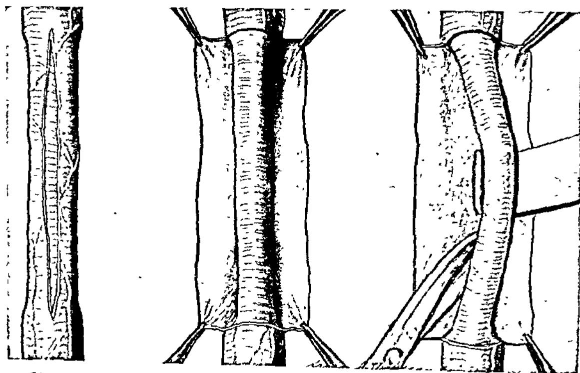


FIGURE 674 Periarterial sympathectomy. Steps in the removal of the adventitia. (Leriche: Nelson's Loose-Leaf Surgery Vol. III.)

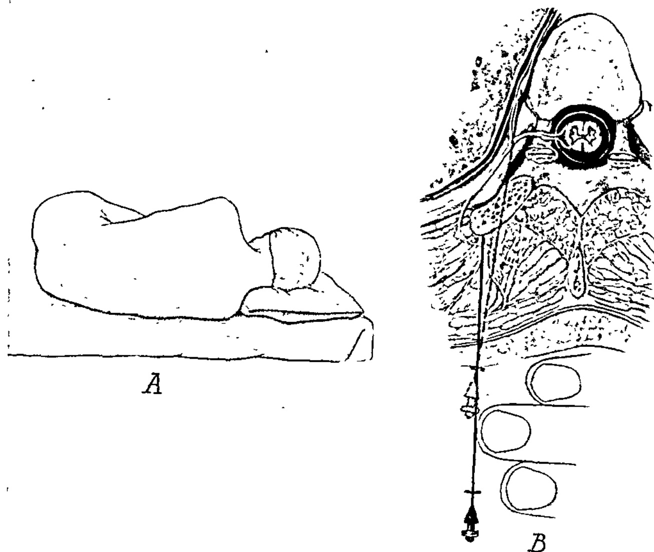


FIGURE 673. Lumbar sympathetic block. *A*, Patient in lateral recumbent position. *B*, Needle inserted vertically until transverse process is reached. Direction of needle changed slightly toward midline and further inserted approximately 2½ finger breadths beyond the transverse process until its point lies near the anterolateral surface of the body of the vertebra at the location of the sympathetic chain. Five cubic centimeters of 1 per cent procaine hydrochloride are injected anterior to the first, second, third and fourth lumbar transverse processes. (After Ochsner and DeBakey: Arch Surg)

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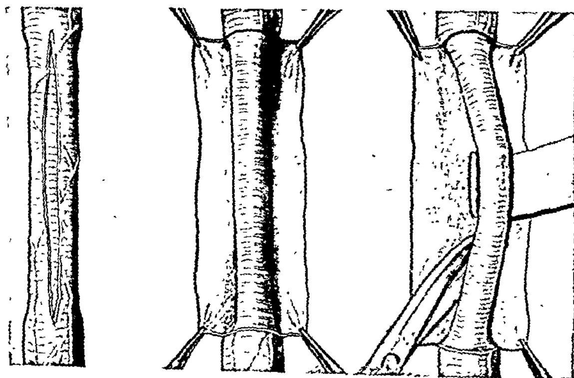


FIGURE 674 Periarterial sympathectomy. Steps in the removal of the adventitia. (Leriche: Nelson's Loose-Leaf Surgery Vol. III.)

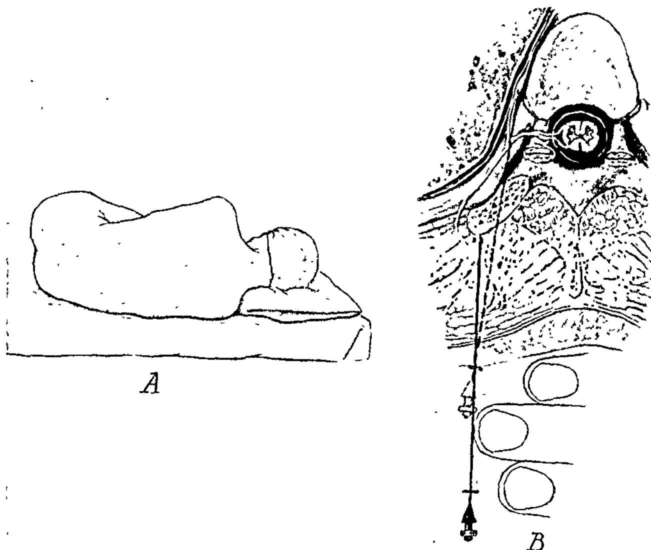


FIGURE 673. Lumbar sympathetic block. *A*, Patient in lateral recumbent position. *B*, Needle inserted vertically until transverse process is reached. Direction of needle changed slightly toward midline and further inserted approximately 2½ finger breadths beyond the transverse process until its point lies near the anterolateral surface of the body of the vertebra at the location of the sympathetic chain. Five cubic centimeters of 1 per cent procaine hydrochloride are injected anterior to the first, second, third and fourth lumbar transverse processes. (After Ochsner and DeBakey. Arch Surg.)

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This operation probably has limited therapeutic value, although good reports of its use have been recorded. It has been used for various disorders of circulation of the extremities such as senile and diabetic gangrene, intermittent claudication, causalgia, painful amputation stumps, trophic ulcers, thromboangiitis obliterans, scleroderma, Raynaud's disease, acrocyanosis and certain edemas.

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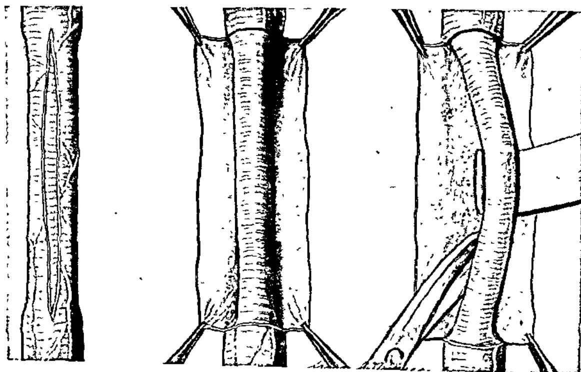


FIGURE 674. Periarterial sympathectomy. Steps in the removal of the adventitia. (Leriche: Nelson's Loose-Leaf Surgery Vol. III.)

CERVICOTHORACIC GANGLIONECTOMY

General Considerations

Interruption of the upper thoracic and cervical sympathetics has been done for a number of different conditions with varied success. Varied vasospastic conditions involving the upper extremities such as Raynaud's disease, Raynaud's phenomenon, reflex sympathetic dystrophy and thromboangiitis obliterans have shown marked benefit from sympathetic denervation. In addition, hyperhydrosis of the face and upper extremity may be corrected by this procedure. Other conditions such as epilepsy, asthma, migraine, trigeminal neuralgia, arthritis and cerebral thrombosis have not been benefited by sympathectomy. Angina pectoris and coronary disease have been treated by stellate ganglionectomy, but the procedure has been abandoned for the most part for these conditions.

The operation may be done by an anterior supraclavicular approach or by a posterior extrapleural approach. The posterior approach, although technically somewhat more difficult, has several advantages. Sympathectomy is more complete and the regeneration of nerve fibers is less apt to occur. By means of this approach a preganglionic sympathectomy is obtained, and in addition a Horner's sign is not produced.

Technique of Operation (Posterior Extrapleural Approach) (Figs. 675, 676)

This procedure is based on the fact that the sympathetic outflow to the upper extremity comes by way of the upper thoracic nerves, chiefly the second and third, and that no outflow passes directly from the cervical nerves to the roots comprising the brachial plexus.

Endotracheal anesthesia is used, and the patient is placed in the facedown position. The incision is planned so that its center lies at a level opposite the spinous process of the second thoracic vertebra, which in turn is the level of the third rib. A slightly curved incision approximately 3 inches in length is made in the paravertebral region of the side to be removed. The fibers of the trapezius muscle are then divided, as are those of the rhomboid muscle which lie immediately beneath the trapezius. In small, thin-muscled patients adequate exposure may be obtained by splitting these muscles in the line of their fibers in a gridiron fashion; however, in heavy-muscled patients it usually is necessary to cut across the fibers of one or both muscles. This brings into view the paravertebral fascia, which is likewise divided. Careful palpation beneath this layer then makes it possible to identify accurately the third rib. The inner segment of the third rib is then stripped of its surrounding periosteum and a segment removed. The innermost portion of the rib as well as the tip of the transverse process of the third thoracic vertebra is removed with rongeurs in order to obtain adequate visualization of the sympathetic chain.

The underlying pleura usually separates without difficulty. If additional exposure is required, a segment of the inner portion of the fourth rib can be removed in a similar fashion. The second and third intercostal nerves are then separated from the other structures of the intercostal bundle. These nerves are followed toward their site of emergence from the spinal canal. The dorsal branch of the nerve is divided, and this usually affords ample visualization of the anterior and posterior nerve roots. The

nerve roots are then divided, and a segment of the intercostal nerve approximately 3 inches in length is removed. Both the second and the third intercostals are removed in this fashion. There may be leakage of a small amount of cerebrospinal fluid when the roots are divided if the root sleeve is damaged. Some authors recommend avulsion of the nerve roots to prevent regeneration. This leakage of cerebrospinal fluid can be controlled by a pack or a small piece of Gelfoam. The sympathetic chain is then cleaned of all communicating fibers and divided as low as possible. If only the third rib has been removed, the division will be at the level of the fourth ganglion. The first intercostal nerve and rami communicantes are preserved. The lower end of the sympathetic chain is then sutured into the paravertebral muscles without removing any of the chain. The entire area is carefully checked for hemostasis and the wound closed in layers with interrupted sutures without drainage. A catheter is placed in the retropleural space and aspirated with a bulb syringe to be withdrawn as the final sutures are placed to ensure complete expansion in this region. A small dressing is applied.

When done in this fashion, sympathectomy will result in a warm dry hand and arm and there will be no Horner's sign present. By removing the intercostal nerves back to the nerve roots and leaving the sympathetic ganglia intact to be sutured into the paravertebral muscles, the likelihood of regeneration is minimized.

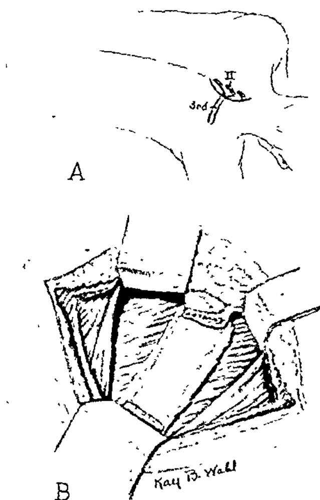


FIGURE 675. Posterior cervicothoracic ganglionectomy. *A*, Position of the patient. The incision is centered over the second spinous process. *B*, The fibers of the trapezius and rhomboid muscles are divided in the line of their fibers in gridiron fashion, permitting removal of the proximal portion of the third rib.

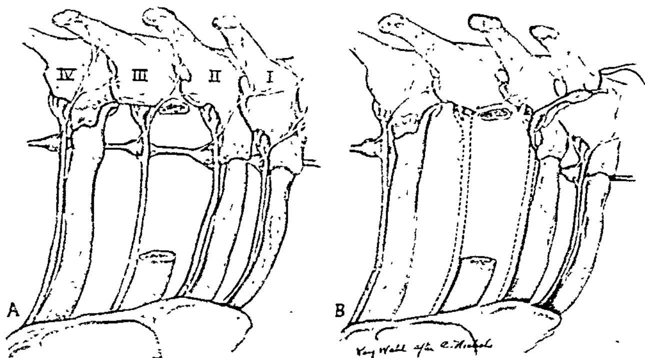


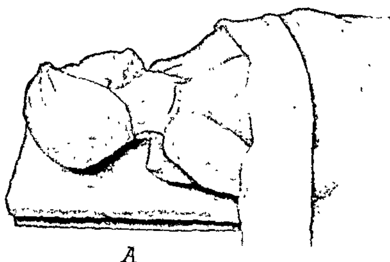
FIGURE 676. Posterior cervicothoracic ganglionectomy (*concluded*). *A*, Illustrating the anatomy of the upper thoracic sympathetic chain and ganglion The inner portion of the third rib and transverse process are removed. *B*, The inner segments of the second and third intercostal nerves have been removed. The sympathetic chain is divided at the level of the fourth ganglion and the end of the chain sutured into the paravertebral muscles to prevent regeneration of fibers.

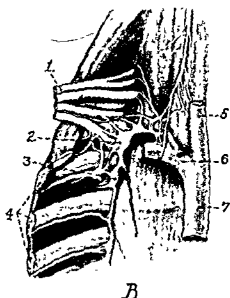
Technique of Operation (Anterior Approach) (Fig. 677)

General anesthesia with apparatus available for positive pressure is preferred. Regional anesthesia may be used in selected cases. The infiltration of procaine and epinephrine to supplement the general anesthetic is valuable in controlling oozing from small vessels.

A supraclavicular incision 7 to 8 cm. long is made just above and parallel to the medial end of the clavicle (Gask and Ross). The clavicular head of the sternocleidomastoid muscle and the posterior belly of the omohyoid muscle are divided or retracted in small-muscled patients. The scalenus anticus muscle and phrenic nerve are exposed. The nerve is retracted with a deep, narrow-bladed retractor, and the muscle with its sheath is completely severed near its insertion into the first rib. This exposes the second part of the subclavian artery. This artery is dissected free, exposing the thyroid axis and the vertebral arteries. The thyroid axis is doubly ligated and severed. On the left, injury to the thoracic duct must be avoided. By retracting the subclavian artery downward and forward and incising Sibson's fascia along the inner border of the first rib, the pleura is exposed. The pleura is carefully stripped from the first three ribs and adjacent vertebrae by gauze and finger dissection and held forward and outward with a flat illuminated retractor.

The inferior cervical ganglion (this may be fused with the first thoracic ganglion to form the stellate ganglion) lies in a groove on the neck of the first rib. From this the thoracic trunk may be followed downward over the heads of the ribs. Over the head of the third rib the trunk is hooked up and severed below the second thoracic ganglion. Any small bleeding vessels are best controlled by Cushing silver clips.





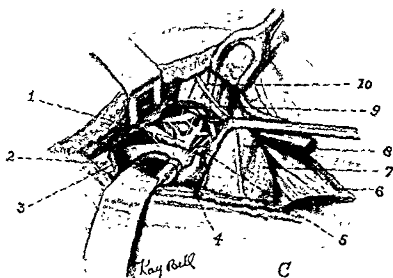


FIGURE 677. Anterior cervicothoracic ganglionectomy. *A*, Location of incision.

B *1*, Brachial plexus; *2*, inferior cervical ganglion; *3*, first thoracic ganglion; *4*, first, second and third ribs, *5*, carotid artery, *6*, subclavian artery; *7*, innominate artery.

C: *1*, Inferior cervical ganglion; *2*, omohyoid muscle; *3*, pleura; *4*, subclavian artery; *5*, thyroid axis; *6*, sternocleidomastoid muscle; *7*, jugular vein; *8*, carotid artery; *9*, phrenic nerve; *10*, scalenus anticus muscle.

ering the sympathetic trunk below the second thoracic ganglion, the fully freed from below upwards by severing all rami up to the inferior glion. The inferior cervical and *upper two thoracic ganglia* are then

e is any oozing, a small rubber tissue drain is inserted to be removed in twenty-four to forty-eight hours. The sternocleidomastoid and platysma muscles and skin are sutured with fine silk.

LUMBAR SYMPATHETIC GANGLIONECTOMY

General Considerations

This operation has been recommended for vasospastic conditions of the lower extremities such as Raynaud's disease, Raynaud's phenomenon, thromboangiitis obliterans, arteriosclerosis, spinal cord disease or injury with paralysis, hyperhidrosis and chronic ulcers due to various causes. *Bilateral ganglionectomy is indicated when both* lower extremities are involved. The results of ganglionectomy for these conditions have not been all that could be desired, and patients to be subjected to this operation should be selected with care.

*The functions of the bladder, rectum and sexual organs, pregnancy and child*birth are not impaired by this operation if the presacral nerves are not disturbed.

The lumbar sympathetic chain may be approached either by the lateral extraperitoneal technique or by the transperitoneal technique. Bilateral sympathectomy can be accomplished through one incision using the transperitoneal route; most authors, however, prefer the extraperitoneal approach.

Technique of Transperitoneal Approach (Figs. 678, 679, 680)

A spinal anesthetic is preferred with the patient in the Trendelenburg position. Through a paramedian incision the intestines are carefully packed into the upper abdomen to expose the pelvis and sacral promontory. The lateral peritoneal attachment of the sigmoid is incised, and the sigmoid with its mesentery is reflected toward the midline. This will expose the left sympathetic chain of ganglia. The ureter must be identified and protected. The aorta and left common iliac artery are exposed. The genitocrural nerve, which extends obliquely downward over the psoas muscle in the operative field, is identified. The ganglia lie just beneath the edge of the aorta in the gutter between the psoas muscle and the vertebrae. The ganglia must be differentiated from the lymphatic nodes in this region.

The fourth lumbar ganglion should be identified first. It lies beneath the margin of the left common iliac artery near the aortic bifurcation. It is exposed by blunt dissection, grasped with a hemostat and freed by dividing the surrounding areolar tissue and sympathetic rami By using the fourth ganglion as traction, the trunk is dissected upward and severed above the second lumbar ganglion to remove in one piece the second, third and fourth ganglia with the connecting sympathetic trunk. The second and third ganglia may be found united into an elongated single ganglion. After all bleeding has been carefully controlled the peritoneum is closed.

The sympathetic chain on the right is exposed by incising the posterior peri-

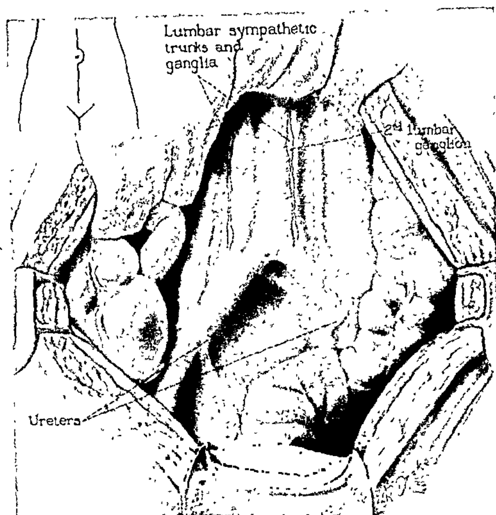


FIGURE 678. General topography of the lumbar area, and the relations between the vessels, ureters and sympathetic trunks are shown. Insert shows type of incision used. (Adson and Brown: Surg., Gynec. & Obst., Vol. 48. By permission of Surgery, Gynecology and Obstetrics)



FIGURE 679. Exposure and resection of the left sympathetic trunk, with the second, third and fourth lumbar ganglia. (Adson and Brown: Surg, Gynec. & Obst, Vol 48. By permission of Surgery, Gynecology and Obstetrics)

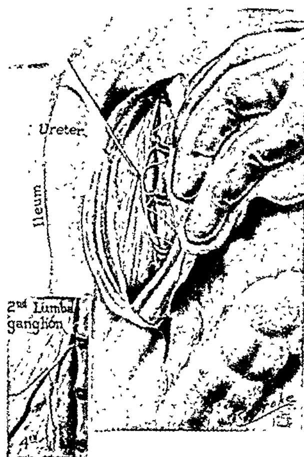


FIGURE 680. Exposure and resection of the right sympathetic trunk, with the second, third and fourth lumbar ganglia. (Adson and Brown· Surg., Gynec. & Obst., Vol. 48. By permission of Surgery, Gynecology and Obstetrics.)

toneum just lateral to the border of the vena cava. The ureter is identified and reflected forward with the peritoneum. The sympathetic trunk bears the same relation to the vena cava and the common iliac vein on the right that it bears to the aorta and common iliac artery on the left. The inferior vena cava is retracted to the left. On the right the lumbar veins overlying or beneath the sympathetic trunk may be injured. Cushing silver clips are convenient for controlling deeply situated bleeding vessels.

The method of removal of the second, third and fourth ganglia and connecting trunk does not differ from that on the left. The peritoneal wound is closed as on the left. The abdomen is closed without drainage.

Technique of Extraperitoneal Approach (Fig. 681)

Spinal anesthesia is preferred, although the procedure may be done under general anesthesia if desired. The patient is placed in the supine position with the operative side slightly elevated on sand bags. Slight flexion of the hip on the operative side will produce relaxation of the psoas muscle and simplify exposure. An oblique incision is made from the region of the tip of the eleventh rib medialward and to the lateral border of the rectus muscle. The external oblique muscle is then divided in the direction of its fibers. This muscle is retracted, and the internal oblique is divided in a similar fashion. Retraction of the internal oblique muscle then brings into view the fibers of the transversus abdominis muscle, which are split in similar fashion. Care should be taken to avoid opening the peritoneum. The peritoneum is then swept medially and forward, exposing the anterior border of the psoas muscle. The peritoneum is next swept medially off the anterior border of the psoas muscle. The sympathetic chain is then found to lie in close approximation to the anterolateral margin of the vertebral

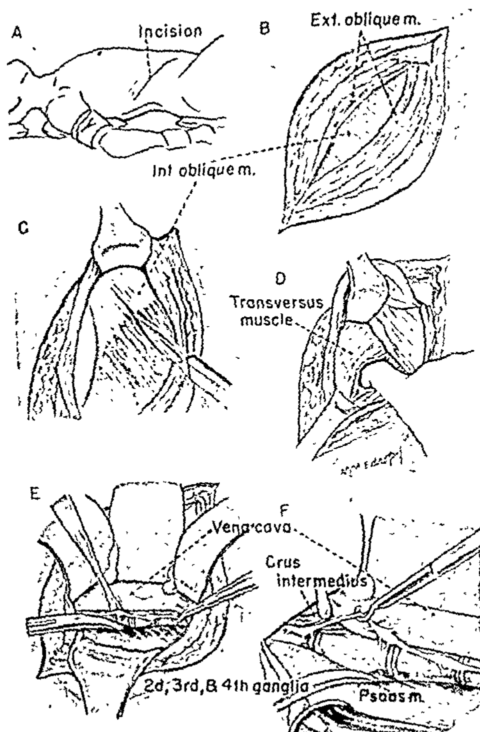


FIGURE 681 Technique of extraperitoneal lumbar sympathectomy. *A*, Position of patient on the operating table, and location of incision. *B*, *C* and *D*, Division of the external oblique muscle, internal oblique muscle and transverse abdominis muscle in the line of their fibers in a gridiron fashion. *E* and *F*, Identification and isolation of the second, third and fourth ganglia from the sulcus between the vena cava, vertebral bodies and inner margin of the psoas muscle. (*Julian*, Ormand C.: S. Clin. North America, Vol 34.)

bodies. On the left side the chain lies in the sulcus between the aorta and inner margin of the psoas muscle. On the right side it lies in the groove between the vena cava and the psoas muscle. If the chain does not come into view readily, it may be identified by palpation.

When the sympathetic chain has been identified, it is retracted forward with a nerve hook or by passing a silk ligature around the chain for traction purposes. The communicating rami are then divided, freeing the chain upward above the second ganglion and downward below the fourth ganglion. The fourth ganglion lies at the level of the sacral promontory. Bleeding is carefully controlled by use of the electrocautery or silver clips. Anatomic variations in this region are frequent, and the second and third ganglia are often fused into one large ganglion. Care must be taken not to injure the large lumbar veins which may pass in front of the sympathetic chain, particularly the fourth lumbar veins. The chain is then divided above the second ganglion and below the fourth ganglion and removed. The area is checked carefully for bleeding, scrupulous hemostasis being essential. The incision is then closed in layers without drainage. If bilateral sympathectomy is to be done, the skin preparation and draping can be so planned and the sand bags placed beneath the opposite side after completion of the first operation.

In obese or heavily muscled patients partial division of one or more of the abdominal muscles may be indicated in order to obtain adequate exposure. In most instances the gridiron type of incision as described will give ample exposure.

CELIAC GANGLIONECTOMY FOR VISCERAL PAIN

General Considerations

Intractable abdominal pain due to tabetic crises, "biliary dyskinesia," chronic pancreatic disease and extensive malignant disease may be benefited by celiac and superior mesenteric ganglionectomy.

Pearl has recorded a case with severe gastric crises successfully treated by celiac ganglionectomy and periarterial sympathectomy of the celiac axis and proximal ends of its branches. Grimson and his associates have obtained good results with celiac and superior mesenteric ganglionectomy in the treatment of recurring pain after cholecystectomy (biliary dyskinesia). These authors recommend excision of the right celiac ganglion, all or part of the left celiac ganglion and the superior mesenteric ganglia.

Technique of Operation (Grimson et al.) (Fig. 682)

After thorough exploration of the abdomen an incision is made in the gastrohepatic ligament medial to the portal vein. The stomach and liver are retracted to expose the aorta near the celiac axis. Fibers of the sympathetic plexus on the surface of the aorta are exposed and traced to the right celiac ganglion. If the splanchnic nerve can be identified, it is traced to the ganglion. As traction is made on the celiac ganglion it is mobilized by dividing its nerve branches. By making traction on the freed celiac ganglion and retracting the celiac and superior mesenteric arteries, the superior mesenteric ganglia and left celiac ganglion can be exposed The right celiac

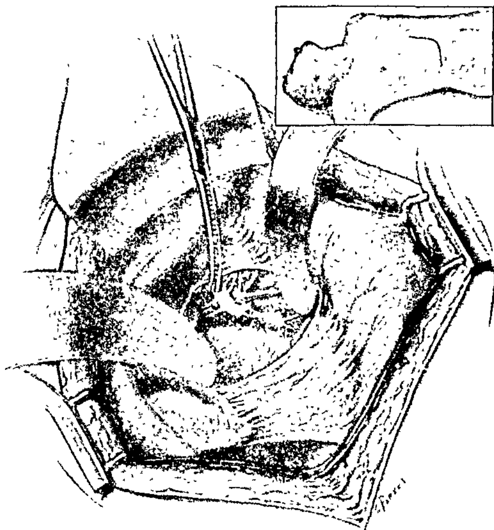


FIGURE 682. Technique of celiac and superior mesenteric ganglionectomy. The ganglia are exposed through an incision in the gastrohepatic ligament medial to the portal vein (Grimson, Hesser and Kitchin· Surgery, Vol. 22, C. V. Mosby Company.)

ganglion, the superior mesenteric ganglia and all or part of the left celiac ganglion are excised.

SYMPATHECTOMY AND SPLANCHNICECTOMY FOR HYPERTENSION

General Considerations

Removal of the sympathetic ganglia and chain as well as the splanchnic nerves in the thoracolumbar region on both sides produces a general reduction in tone of the smooth muscles in the denervated area and abolishes the neurovascular reflex mechanism in the splanchnic bed with a resultant reduction in arterial blood pressure. In addition, sympathetic denervation of the kidneys and adrenals may in some fashion, presumably through a humoral mechanism, produce a favorable effect in the reduction of blood pressure in patients with essential hypertension. Although some twenty years have elapsed since thoracolumbar sympathectomy was first applied to a large number of patients, final evaluation of this procedure cannot be made with certainty as yet. Because of improved results using medical management and drug therapy, the

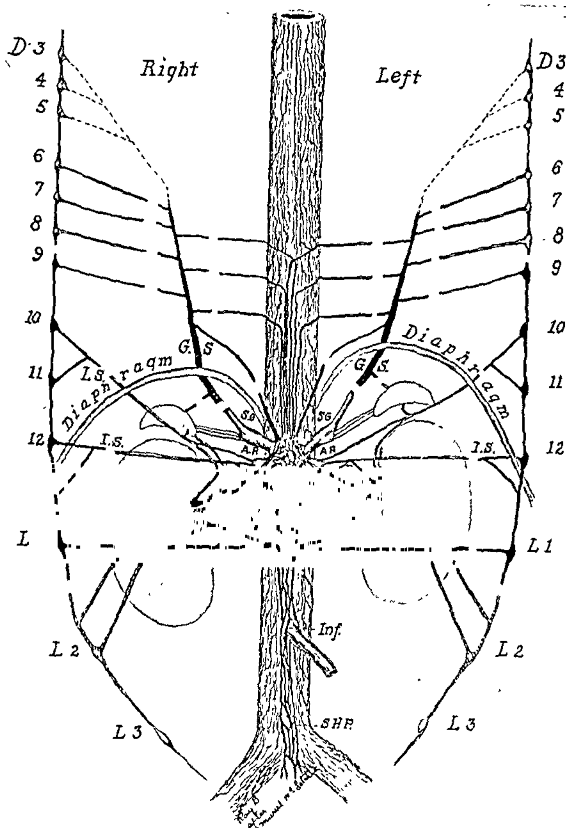


FIGURE 683. Sympathetic nerve supply of splanchnic bed, kidneys and adrenal glands. Areas which can be removed by combined lumbordorsal sympathectomy are drawn in black. (*After White and Smithwick The Autonomic Nervous System, Macmillan Company*)

selection of patients for sympathectomy must be made with even greater caution and discrimination.

The types of sympathectomy and splanchnicectomy which have been used with apparent success are the subdiaphragmatic of Adson, the supradiaphragmatic of Peet, and various combined subdiaphragmatic and supradiaphragmatic operations as devised by Smithwick, Hinton and Lord, Poppen, White, Linton and others (Fig. 683).

Technique of Transpleural Thoracolumbar Sympathectomy (Linton) (Figs. 684, 685, 686)

Endotracheal anesthesia is used. The patient is placed in the lateral position as for routine thoracotomy. A long curved incision is made over the ninth rib, and the pleural cavity is entered through the bed of the ninth rib, which is resected subperiosteally from the costal cartilage to the angle. If high sympathectomy is desired, the eighth rib should be removed in preference to the ninth. The lung is retracted, and the sympathetic chain and great splanchnic nerve are easily identified through the parietal pleura along the posterior thoracic gutter. A vertical incision is then made in the pleura and endothoracic fascia midway between the sympathetic chain and great splanchnic nerve, which emerges by several trunks from the sympathetic chain at various levels from the fourth thoracic down to the seventh or eighth thoracic ganglion. The sympathetic chain is dissected at least as high as the sixth thoracic ganglion by dividing carefully all communicating rami. In patients with angina extension of

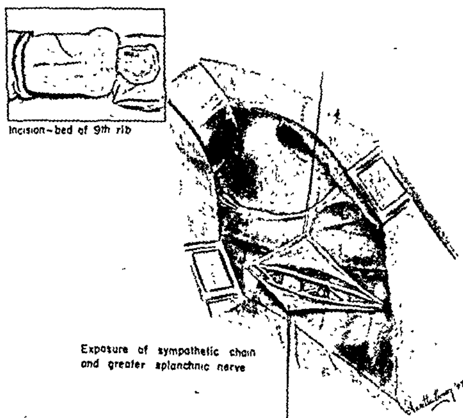


FIGURE 684. Transpleural thoracolumbar sympathectomy A classic lateral thoracotomy incision is made over the ninth rib and the pleural cavity entered through the base of the ninth rib, which is excised subperiosteally. The lung is retracted, and the sympathetic chain and splanchnic nerves are exposed by making a vertical incision in the posterior pleura and endothoracic fascia. (Linton, Moore, Simeone, Welch and White: S. Clin. North America, Vol 27.)

the dissection upward may be indicated to produce sympathetic denervation of the heart. Hemostasis is obtained by electrocautery or clips. In similar fashion the splanchnic system is dissected out carefully. In some instances it may be possible to follow the sympathetic chain and splanchnic nerve downward behind the diaphragm by retracting the diaphragm forward. However, this does not afford adequate exposure in most instances, and the adrenals cannot be examined. It is preferable to divide the diaphragm by making an incision paralleling the twelfth rib a short distance anterior to its attachment.

The tissue plane in the retroperitoneal area can then be developed downward and the sympathetic chain and splanchnic nerves developed. The twelfth thoracic ganglion usually lies in the substance of the diaphragmatic attachment. The sympathetic chain between the twelfth thoracic and first lumbar ganglia is often fine and tenuous. The diaphragmatic crus must be divided in most instances to expose the first lumbar ganglion. The use of a lighted retractor may facilitate dissection in this area. The sympathetic chain is followed downward below the second lumbar ganglion and divided. In the young male patient it may be preferable to leave the lumbar ganglia intact on one side to prevent the loss of ejaculatory power. The great splanchnic nerve is similarly divided just proximal to its entrance into the celiac ganglion. The diaphragm is then reapproximated with interrupted silk sutures, as is the posterior pleural incision, and the lung re-expanded. An intercostal drainage tube is brought

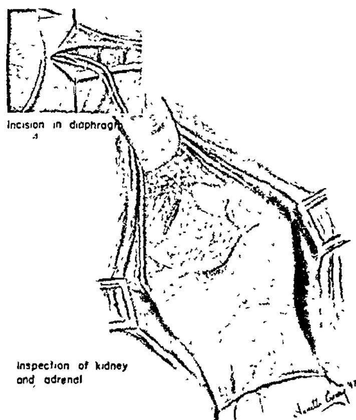


FIGURE 685 Transpleural thoracolumbar sympathectomy (*continued*). When the sympathetic chain and splanchnic nerves have been dissected to their upper limits, the dissection is carried below the diaphragm by making an incision just anterior and parallel with the twelfth rib. This permits exploration of the kidney and adrenal (Linton, Moore, Simeone, Welch and White: S Clin. North America, Vol 27)

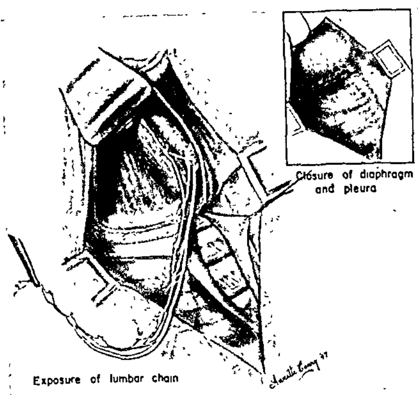


FIGURE 686. Transpleural thoracolumbar sympathectomy (*concluded*). The lumbar chain has been exposed and developed through the diaphragmatic incision. The chain is divided below the second lumbar ganglion and the splanchnic nerve divided at their entrance into the celiac ganglion. Inset shows closure of the diaphragm and posterior pleural incision. (Linton, Moore, Simeone, Welch and White: S Clin. North America, Vol. 27.)

out through a stab wound and placed beneath a waterseal drain, and the chest wall is closed in layers with interrupted silk.

Little change in blood pressure will be noted following division of the chain and splanchnic nerves when the first side is being done. The second side is usually done in ten days to two weeks following the first operation. When the great splanchnic nerve and sympathetic chain are divided during the second stage, there will often be a drop in blood pressure. This can be controlled with norepinephrine or one of the other vasoconstrictor drugs.

After the second operation the patient may experience severe orthostatic hypotension even with slight elevation of the upper portion of the body. For this reason considerable caution must be observed in the resumption of ambulation. Wrapping of the legs and abdomen with elastic bandages may be necessary.

The transpleural procedure permits extensive removal of the thoracic sympathetic chain as well as the splanchnic system.

Extensive Combined Thoracolumbar Sympathectomy (Poppen) (Figs. 687, 688)

The procedures are performed in two stages approximately ten days apart. High spinal anesthesia or endotracheal anesthesia is used. An adequate supply of oxygen is essential. The patient is placed in the lateral semiprone position with the thoracic spine flexed forward to as great a degree as possible. A paravertebral incision is made over the thickest portion of the erector spinae muscles at the line of cleavage of the longissimus dorsi and iliocostalis dorsi muscles, extending from the seventh rib downward and curving slightly anteriorly to the distal portion of the eleventh or twelfth

rib. The medial portions of the eleventh rib and the seventh or eighth rib are then removed for a distance of approximately 4 cm. from the transverse process, *taking* care not to extend the rib removal further laterally than the width of the long spinal muscles. As much rib as possible is removed medially to afford better exposure. The parietal pleura is pushed forward and the greater splanchnic nerve identified along the anterolateral border of the vertebral body. The pleura is then separated by blunt dissection cephalad to the level of the fourth thoracic ganglion and caudad to the

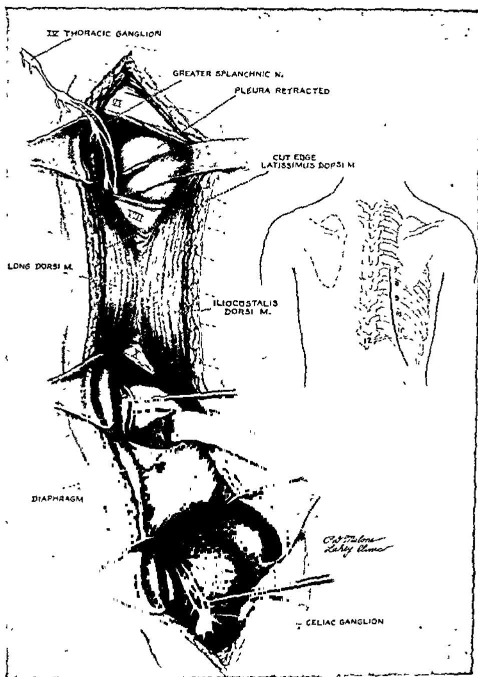


FIGURE 687 Combined thoracolumbar sympathectomy. A long paravertebral incision is used, extending from the level of the seventh rib and curving slightly anteriorly toward the tip of the twelfth rib. A portion of the seventh rib has been removed, as has a portion of the eleventh rib, and the pleura retracted to permit exposure and dissection of the sympathetic chain and splanchnic nerves. In the lower portion of the incision the retroperitoneal space is entered, permitting exposure and dissection of the subdiaphragmatic portion of the sympathetic chain and splanchnic nerves. (*J. L. Poppen: Surgical Practice of the Lahey Clinic*)

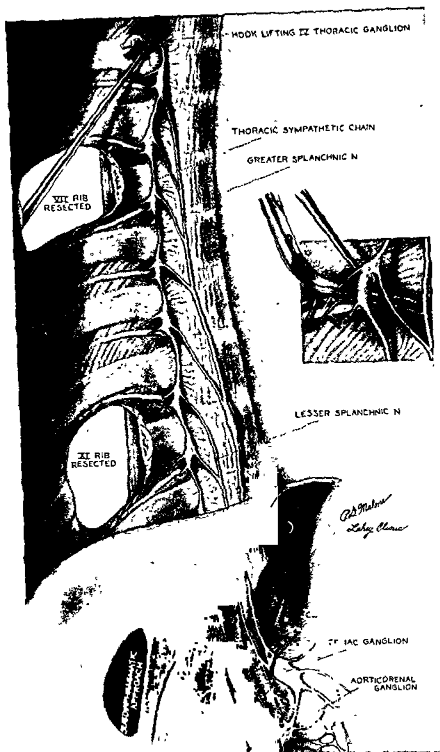


FIGURE 688 Combined thoracolumbar sympathectomy (*concluded*). Drawing of the sympathetic chain and splanchnic system from within, showing the approach to these structures through the resected seventh and eleventh ribs and subdiaphragmatic muscles. The inset demonstrates dissection of the ganglia from the intercostal vessels and division of the rami communicantes. (J. L. Poppen: Surgical Practice of the Lahey Clinic.)

attachment of the diaphragm, taking care not to enter the pleura if possible. The great splanchnic nerve is then mobilized along its entire length.

The main trunk of the splanchnic usually arises from the fifth or sixth ganglion, but may arise as a separate trunk from as high as the fourth ganglion. The sympathetic trunk is next mobilized and all communicating rami carefully divided. This is mobilized above the fourth thoracic ganglion and divided. The entire mobilized upper

rib. The medial portions of the eleventh rib and the seventh or eighth rib are then removed for a distance of approximately 4 cm. from the transverse process, taking care not to extend the rib removal further laterally than the width of the long spinal muscles. As much rib as possible is removed medially to afford better exposure. The parietal pleura is pushed forward and the greater splanchnic nerve identified along the anterolateral border of the vertebral body. The pleura is then separated by blunt dissection cephalad to the level of the fourth thoracic ganglion and caudad to the

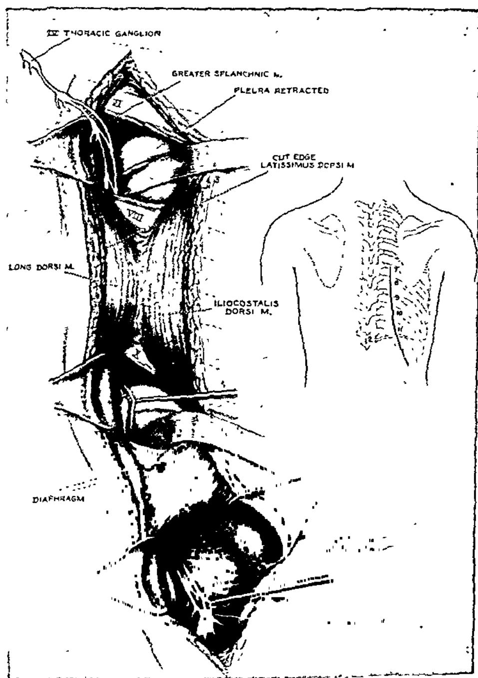


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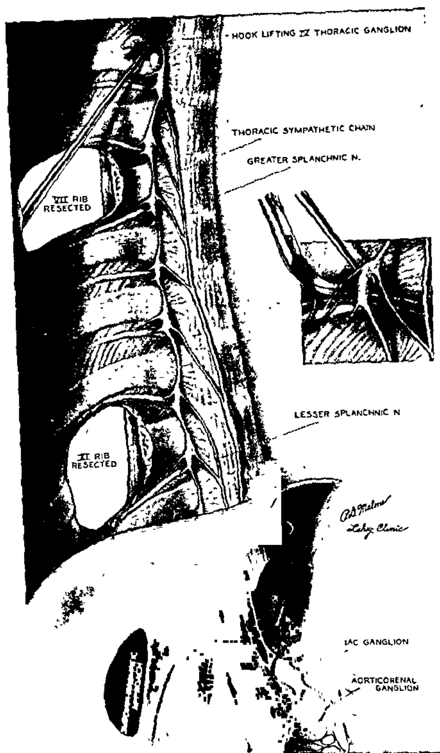


FIGURE 688 Combined thoracolumbar sympathectomy (*concluded*). Drawing of the sympathetic chain and splanchnic system from within, showing the approach to these structures through the resected seventh and eleventh ribs and subdiaphragmatic muscles. The inset demonstrates dissection of the ganglia from the intercostal vessels and division of the rami communicantes. (J. L. Poppen: Surgical Practice of the Lahey Clinic.)

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rib. The medial portions of the eleventh rib and the seventh or eighth rib are then removed for a distance of approximately 4 cm. from the transverse process, taking care not to extend the rib removal further laterally than the width of the long spinal muscles. As much rib as possible is removed medially to afford better exposure. The parietal pleura is pushed forward and the greater splanchnic nerve identified along the anterolateral border of the vertebral body. The pleura is then separated by blunt dissection cephalad to the level of the fourth thoracic ganglion and caudad to the

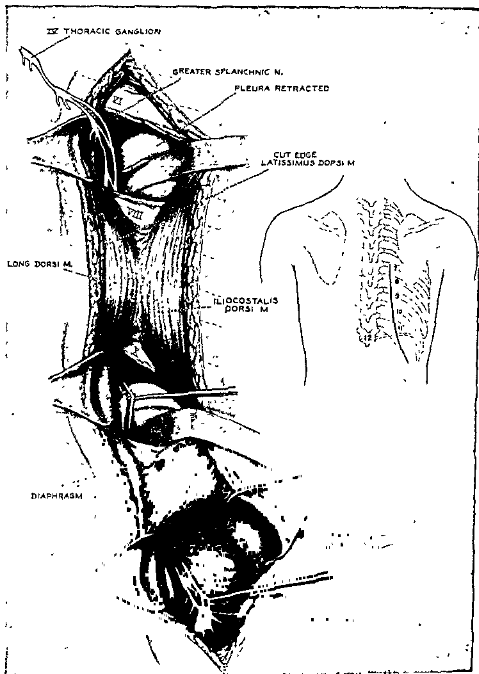


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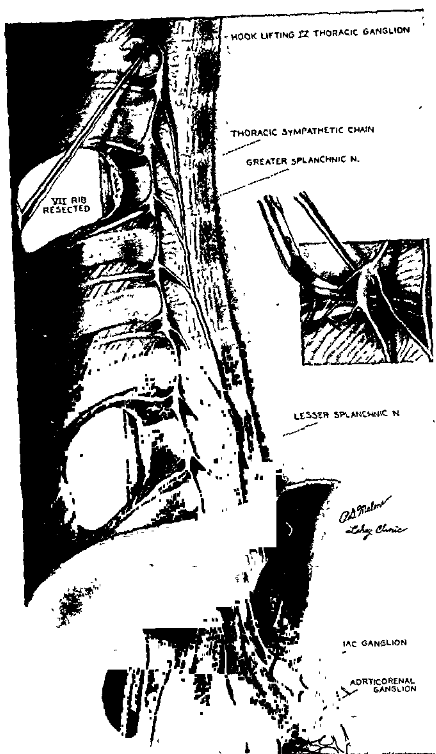


FIGURE 688 Combined thoracolumbar sympathectomy (*concluded*). Drawing of the sympathetic chain and splanchnic system from within, showing the approach to these structures through the resected seventh and eleventh ribs and subdiaphragmatic muscles. The inset demonstrates dissection of the ganglia from the intercostal vessels and division of the rami communicantes. (J. L. Poppen: Surgical Practice of the Lahey Clinic.)

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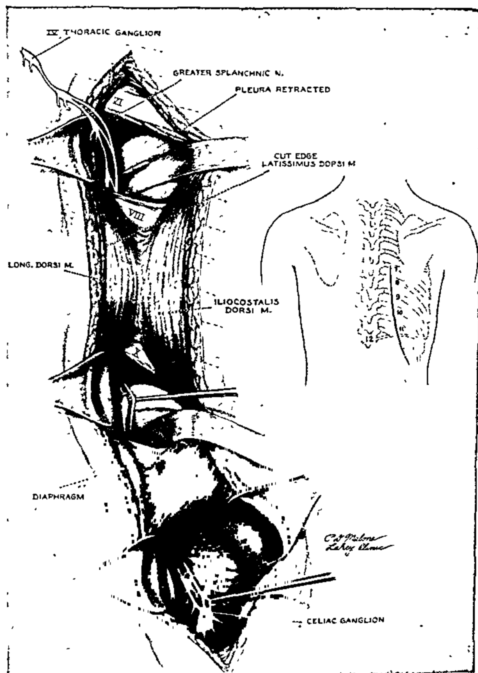


FIGURE 687. Combined thoracolumbar sympathectomy. A long paravertebral incision is used, extending from the level of the seventh rib and curving slightly anteriorly toward the tip of the twelfth rib. A portion of the seventh rib has been removed, as has a portion of the eleventh rib, and the pleura retracted to permit exposure and dissection of the sympathetic chain and splanchnic nerves. In the lower portion of the incision the retroperitoneal space is entered, permitting exposure and dissection of the subdiaphragmatic portion of the sympathetic chain and splanchnic nerves. (J L. Poppen: Surgical Practice of the Lahey Clinic)

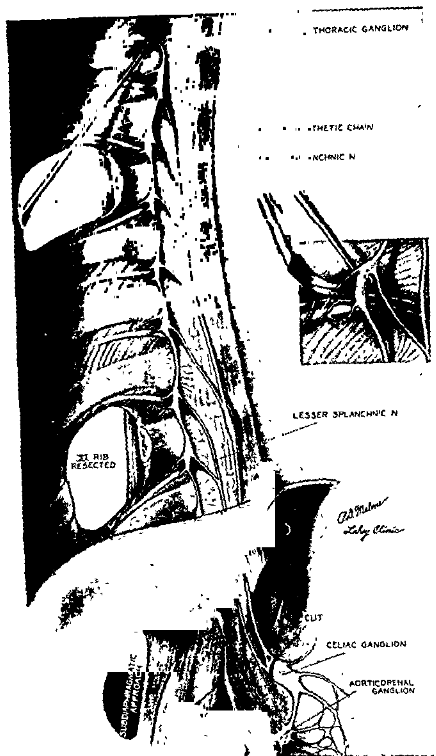


FIGURE 688. Combined thoracolumbar sympathectomy (*concluded*) Drawing of the sympathetic chain and splanchnic system from within, showing the approach to these structures through the resected seventh and eleventh ribs and subdiaphragmatic muscles. The inset demonstrates dissection of the ganglia from the intercostal vessels and division of the rami communicantes. (J. L. Poppen: Surgical Practice of the Lahey Clinic.)

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The main trunk of the splanchnic usually arises from the fifth or sixth ganglion, but may arise as a separate trunk from as high as the fourth ganglion. The sympathetic trunk is next mobilized and all communicating rami carefully divided. This is mobilized above the fourth thoracic ganglion and divided. The entire mobilized upper

sympathetic trunk and branches are then pulled down through the aperture made by removal of the eleventh rib. If possible, the entire chain and splanchnic system are kept intact from above downward to ensure complete removal.

After the thoracic chain and splanchnic nerves have been mobilized in continuity down to the diaphragm, the sacrospinalis muscle in the lower border of the incision is retracted medially, permitting division of the lumbodorsal fascia and transversalis fascia. This permits entrance into the retroperitoneal space. The splanchnic nerves are then identified as they pass through the diaphragm, dissected and detached from the celiac ganglion. The lumbar sympathetic chain is then identified. In the female the third lumbar ganglion is mobilized and the trunk immediately beneath it divided. The chain is then dissected upward, taking care to separate all communicating fibers. The first lumbar ganglion is usually covered by the diaphragmatic crus, which must be incised. In this fashion the lumbar chain can be mobilized and pulled through the aperture in the diaphragm upward to be removed from above, thus permitting removal of the entire sympathetic chain and ganglia along with the splanchnic nerves in continuity.

Bleeding points throughout can be controlled with electrocautery or silver clips. In young male patients it is best to leave the first lumbar ganglion intact at least on one side in order to preserve ejaculation. The wound is then closed in layers with fine nonabsorbable sutures.

The use of norepinephrine or other vasoconstrictor agents may be necessary to control hypotension after and during the second-stage operation.

Technique of Transdiaphragmatic Sympathectomy and Splanchnicectomy (Smithwick)

General anesthesia is used. With the patient in the prone position, the chest and pelvis are supported so as to avoid pressure on the abdomen. Exposure is improved by breaking the operating table slightly. A hockey stick incision is made beginning over the ninth rib 3 to 4 cm. from the midline and extending vertically downward to a point slightly below the twelfth rib, where it curves laterally parallel with the twelfth rib to the iliac crest. The dissection is carried downward through the deep fascia and fibers of the latissimus dorsi muscle above and through the lumbodorsal fascia and oblique abdominal muscles below. The lateral edge of the sacrospinalis muscle sheath is incised laterally, elevated and the muscle retracted medially, thereby exposing the eleventh and twelfth ribs. The twelfth rib and approximately the inner 8 cm. of the eleventh rib are removed subperiosteally. The intercostal bundles are left intact, although it may be necessary to divide the twelfth bundle. The pleura is then separated from the thoracic cage by blunt dissection. The pleura tears easily, but this does no harm if the intrathoracic pressure is controlled by the anesthetist. The renal fascia is then incised laterally and downward to expose the retroperitoneal space, and divided. The kidney and adrenals are then carefully examined. The kidney is retracted medially and the inner margin of the psoas muscle depressed, revealing the lumbar portion of the sympathetic chain lying in the sulcus between the inner margin of this muscle and the vertebral bodies. Tilting of the operating table about 30 degrees away from the operator's side may aid in exposure at this point.

The sympathetic chain and ganglia are then dissected both below and above the

diaphragm, and all rami communicantes are divided. The chain is removed from above the eighth thoracic ganglion downward to include the second lumbar ganglion and occasionally the third lumbar ganglion in the female. In male patients it is best to stop the downward dissection just above the first lumbar ganglion if ejaculation is to be preserved in all patients, although effectiveness of the operation may be compromised considerably. After the thoracolumbar chain has been removed the great splanchnic nerve is identified and divided just above its entrance into the celiac ganglion. It is then freed upward by blunt dissection and divided as high as possible.

The diaphragm and incision are then carefully closed with silk interrupted sutures without drainage. A catheter is placed in the extrapleural space and aspirated of any residual air as the incision is closed. If the pleura has been entered, a catheter is placed in the pleural cavity and aspirated of all air and removed as the last stitches are being tied. After the first-stage operation little change in blood pressure will be noted; however, after the second stage, which is carried out approximately ten days later, marked orthostatic hypotension may ensue during and after operation. This can be controlled with norepinephrine or other vasopressor agents as well as mechanical support to the lower extremities and abdomen with elastic bandages.

With this operation Smithwick has noted a lower blood pressure in all positions of the patient with a definite fall in pressure in the sitting or standing posture. He believes that removal of virtually all of the great splanchnic nerve with division of all the aortic branches and interruption of the communicating rami of the ninth, tenth, eleventh and twelfth dorsi and first lumbar ganglia with excision of the sympathetic trunk over this area is the minimal procedure which will consistently produce the desired change in blood pressure.

Technique of Combined Subdiaphragmatic and Supradiaphragmatic Sympathectomy and Splanchnicectomy (Hinton and Lord) (Figs. 689, 690, 691)

The patient is placed on the operating table in a lateral position. If the twelfth rib is long, the tenth rib is completely resected subperiosteally. If the twelfth rib is short, the ninth rib is resected. An incision is made down to the pleura in the rib bed, and the pleura is reflected from the posterolateral chest wall. This reflection of the pleura exposes the diaphragm, which is completely divided. Good exposure is obtained by retracting the parietal pleura with its contained lung and the retroperitoneal fat below the diaphragm with large Harrington retractors.

The greater splanchnic nerve is dissected free at its lower end and divided at its junction with the celiac ganglion. Beginning below the second lumbar ganglion, the sympathetic chain, with the splanchnic nerves, is removed up to and including the third thoracic ganglion. The communicating rami are divided several millimeters from each ganglion. The twelfth ganglion is found above or in the substance of the diaphragm There is often a wide variation in size and distribution of the nerves.

The wounds in the diaphragm and chest wall are closed with interrupted cotton sutures. If the pleura has been torn, a rubber catheter is inserted into the pleural space, and at the completion of the wound closure the intrapleural air is aspirated and the catheter is removed.

The opposite side is operated upon within seven to ten days following the first operation if the condition of the patient is satisfactory.

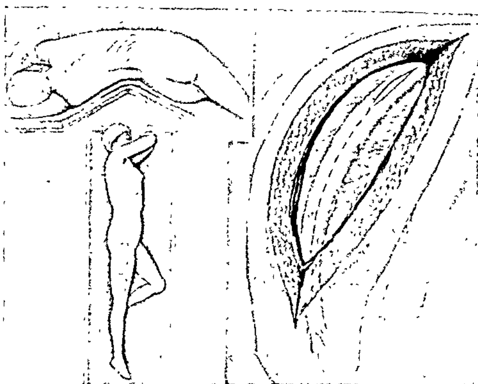


FIGURE 689. Technique of combined subdiaphragmatic and supradiaphragmatic sympathectomy and splanchnicectomy. *A*, *B*, Position of patient on the operating table. *C*, Type of incision made over the tenth or ninth rib. (Hinton and Lord: Surg., Gynec. & Obst., Vol. 83. By permission of Surgery, Gynecology and Obstetrics.)

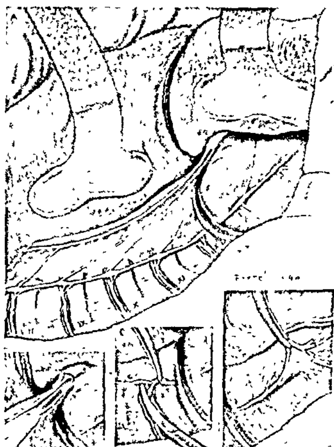


FIGURE 690. Technique of combined subdiaphragmatic and supradiaphragmatic sympathectomy and splanchnicectomy (*continued*). Details of isolation and division of the splanchnic nerve at the celiac ganglion and the sympathetic chain below the second lumbar ganglion. (Hinton and Lord: Surg., Gynec. & Obst., Vol. 83. By permission of Surgery, Gynecology and Obstetrics.)

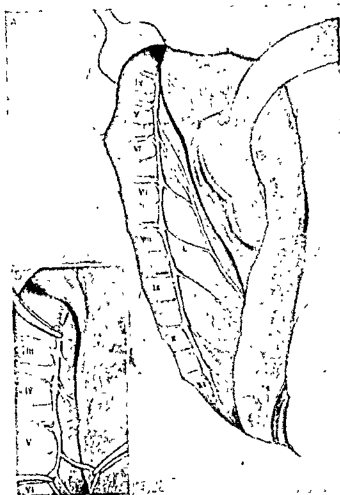


FIGURE 691 Technique of combined subdiaphragmatic and supradiaphragmatic sympathectomy and splanchnicectomy (*concluded*). *A*, Exposure of the thoracic sympathetic chain and the splanchnic nerves by retracting the pleura. *B*, Detail of division of sympathetic chain above the third thoracic ganglion (Hinton and Lord. Surg., Gynec. & Obst, Vol. 83 By permission of Surgery, Gynecology and Obstetrics)

PRESACRAL NEURECTOMY

General Considerations

Excision of the superior hypogastric plexus may be indicated for relief of spasm of the bladder sphincter resulting from spinal cord disease or injury and for the relief of intractable pain in the uterus (dysmenorrhea), bladder or rectum.

Removal of the presacral nerves causes a loss of the power of ejaculation, but the power of erection and sensation of orgasm are not impaired. In the female, it is generally believed that the sexual function, pregnancy and childbearing are not disturbed. Meigs reports that there may be some interference with the nerve supply to the vagina which prevents successful orgasm.

Technique of Operation (Fig. 692)

Spinal anesthesia is advised. A paramedian incision is made extending from 3 cm. above the pubes to 5 cm. above the umbilicus. The Trendelenburg position is essential for good exposure. Exposure of the bifurcation of the aorta and presacral area is obtained by packing the intestines upward in the abdomen.

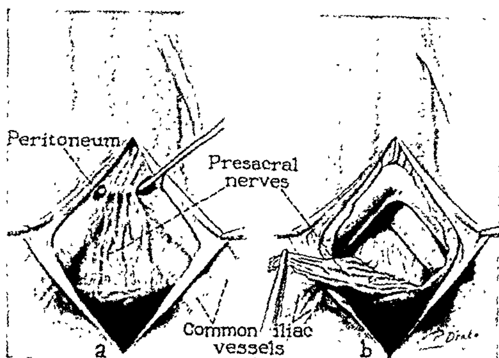


FIGURE 692. Technique of presacral neurectomy. *a*, Elevation of the presacral nerves as they cross the bifurcation of the aorta. *b*, Illustrating the method of presacral nerve resection. (Adson: Surgery, Vol. I, C. V. Mosby Company.)

The posterior peritoneum is incised from a point 2 cm. above the bifurcation of the aorta downward to a point 5 cm. below. The peritoneal margins are carefully dissected up and retracted. The superior hemorrhoidal vessels are drawn to the left. The presacral nerves lie in the exposed area with lymphatics and loose connective tissue. The nerves may be visible in thin patients.

In order not to miss any nerve fibers, the hollow of the sacrum between the common iliac arteries is cleaned out. It may be necessary to ligate the middle sacral artery. A possible danger is injury to the left common iliac vein, which lies medial to the artery. The right ureter is usually exposed. Where the nerves cross the aortic bifurcation, they are picked up in a group with a hook and freed downward by blunt dissection with a cotton pledget. All communicating rami are cut as the dissection progresses. Both common iliac arteries and veins are denuded over a length of 3 cm. All fine nerve fibers must be removed. The base of the triangle over the hollow of the sacrum is ligated to prevent oozing from small vessels and seepage of lymph. The peritoneal incision is closed with fine catgut or silk, and the abdominal wound is closed without drainage.

EXCISION OF CAROTID BODY TUMOR

Indications

The treatment of choice is excision. When operation is considered too dangerous or because of technical difficulties removal has been abandoned, x-ray or radium therapy may be tried.

Dangers and Safeguards

Tumors of the carotid body lie at the bifurcation of the carotid artery and may partially surround or be so adherent to the common, internal or external carotid that

excision is impossible without sacrifice of these vessels. Ligation of the internal carotid artery results in hemiplegia and death in a high percentage of patients of advanced years. The frequency of this complication has been estimated to be from 20 to 54.5 per cent. The external carotid may be ligated with a minimum of danger. Carotid tumors are very vascular, and hemorrhage may be an important danger in their removal. McNealy and Hedin advise that operation be abandoned if it is found necessary to ligate the common or internal carotid artery. With present-day blood vessel replacement techniques a homograft or prosthesis may be inserted if the artery must be sacrificed.

Harrington and his associates have made the statement that tumors of the carotid body are always malignant or potentially malignant, but rarely recur or metastasize after complete removal. Lahey and Warren disagree and estimate that 15 to 20 per cent of carotid body tumors are malignant. There was no proved instance of malignancy observed in eighteen cases at the Lahey Clinic.

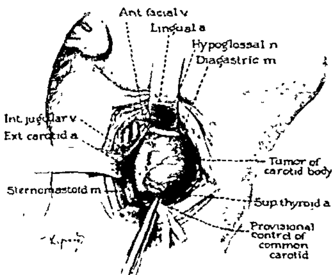


FIGURE 693. Incision and exposure of carotid body tumor. (McNealy and Hedin J. Internat. Coll. Surgeons, Vol 2.)

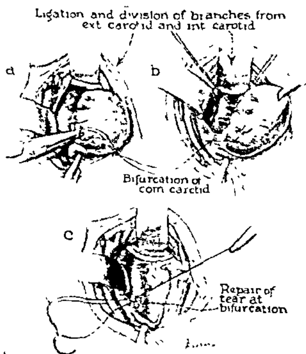


FIGURE 694 *a*, Ligation of individual vessels of carotid tumor. *b*, External carotid artery retracted and internal carotid brought into view. *c*, Suture of carotid at its bifurcation may be necessary if tumor has been firmly attached at this point (McNealy and Hedin: J Internat. Coll Surgeons, Vol. 2.)

Dangers and Safeguards

Careful preoperative treatment of patients with toxic goiters or damaged hearts is the first requisite. With the exception of large goiters producing pressure and interfering with respiration, emergency operations are rarely indicated.

During an operation upon the thyroid gland the three most important complications which may arise are *hemorrhage, injury to the recurrent laryngeal nerves* and *injury to the parathyroids.* A thorough knowledge of the anatomy of the neck is necessary before attempting operation upon the thyroid. The thyroid has an abundant blood supply which varies within wide limits in different types of goiter. When vessels are severed, they will often retract, and their recovery with hemostats may endanger vital structures. The secure clamping and ligation of important vessels will prevent such complications.

The recurrent laryngeal nerves are exposed to constant danger during thyroidectomy. They may be injured by clamping, cutting, ligation, tearing, overstretching by traction on the gland, or rough dissection. The function of these nerves may also be disturbed by postoperative formation of blood clots and edema. The best way to avoid nerve injury is to know where they are and stay away from them. Lahey recommends routine dissection and demonstration of the recurrent laryngeal nerves beneath and below the lower pole before excising a thyroid lobe. He is able to palpate the nerve by pushing it against the trachea.

Recurrent laryngeal nerve injury results in *paralysis of the vocal cords.* If this occurs on both sides, closure of the glottis may occur, embarrassing respiration to the extent that a tracheostomy may be necessary. Preoperative examination of the larynx is advised in all cases. Pressure of an enlarged thyroid or carcinoma of the gland may injure the nerve and cause paralysis of the vocal cords. To avoid embarrassing situations, it is important to know the condition of the vocal cords before operation. Repair of the severed nerves is difficult and usually offers little hope of complete restoration of vocal cord function.

Sudden release of prolonged compression of the trachea may result in *interference with breathing* due to collapse of the tracheal wall. Dyspnea may also be due to traction on or torsion of the trachea. Obstruction of the trachea requiring tracheostomy may be caused by pressure from a blood clot or edema. When operating upon large goiters with tracheal deformity, it is wise to divide the isthmus and expose the trachea as the first step so that tracheostomy may be done, when necessary, with minimum difficulty.

Removal of the parathyroids may produce *tetany.* If a parathyroid gland is found attached to a resected lobe of the thyroid, it should be immediately implanted into the sternocleidomastoid muscle. Operation performed within the thyroid capsule will rarely damage either the parathyroid or recurrent laryngeal nerves. A portion of the gland left attached to the posterior capsule covering the sulcus between the trachea and esophagus will also aid in protecting both nerves and parathyroids.

The *quantity of thyroid tissue to be left* must necessarily depend upon the type of goiter. Resection of a toxic goiter must be extensive to avoid recurrence of symptoms. The larger the goiter, the larger the remnants that may be left. In children a relatively larger remnant should be left than in the adult. On the basis of a weight-measure study of thyroid tissue, Smith has concluded that 6 to 7 gm. of thyroid should be left

to reduce failure to a minimum. A block of tissue on each side measuring 3 by 1 by 1 cm. will approximate 5 to 6 gm. in weight. When large glands with low toxicity or adenomas are removed, larger remnants of thyroid tissue may be left without fear of recurring symptoms.

To avoid technical difficulties in the removal of large thyroids, it is better to divide the sternothyroid and sternohyoid muscles. These should be divided high to avoid damage to their nerve supply.

Drainage following thyroidectomy is not necessary when all bleeding is carefully controlled. When considered necessary, a rubber tissue drain is brought out of the incision, to be removed in twenty-four hours. Rarely, excessive bleeding with impending shock may require packing of the wound and secondary closure.

Ligation of the thyroid arteries preliminary to thyroidectomy is seldom necessary since the introduction of iodine therapy as a preliminary treatment of hyperthyroidism.

The choice of suture and ligature material is a matter of personal preference of the surgeon. It is generally believed that fine silk or cotton causes less tissue reaction than catgut. If catgut is used, it should be of small size.

SUBTOTAL THYROIDECTOMY

General Considerations

The successful use of radioactive iodine in the management of patients having primary hyperthyroidism has led to a careful re-evaluation of the indications for subtotal thyroidectomy in this condition. I^{131} if given in sufficient dosage will cure patients with hyperthyroidism. Because of the possibility that radioactive iodine may be carcinogenic, as well as the possibility of mutation changes in the ovaries, there has been considerable hesitation in using this method of treatment for younger patients. In addition, because of the difficulties in determining the exact dosage required, the incidence of myxedema is greater following I^{131} treatment than it is following subtotal thyroidectomy. With improved preoperative preparation, anesthesia and surgical technique the morbidity and mortality figures associated with subtotal thyroidectomy have been so small and the permanent cure so good that many authors have been unwilling to abandon this method of treatment and reserve the use of radioactive iodine to patients over fifty years of age or for younger patients with recurrent hyperthyroidism.

Preoperative Preparation

The introduction of iodine into the preoperative treatment of hyperthyroidism by Plummer in 1923 simplified greatly the technical problems encountered when operating on patients with hyperthyroidism. However, the problem of bleeding during the operative procedure and the occurrence of postoperative thyroid storm remained, particularly in patients with severe hyperthyroidism. The introduction of the antithyroid drugs around 1940 made it possible to bring the patient to a euthyroid state before operation. One of the antithyroid drugs such as propylthiouracil is administered until the basal metabolic rate has returned to normal. Since these agents do not produce involution of the gland, it is advisable to administer Lugol's solution in

addition during the last two to three weeks of preoperative preparation. When preoperative preparation is carried out in this fashion, the technical problems encountered during subtotal thyroidectomy for hyperthyroidism are lessened and the postoperative problems encountered are few.

It is customary to visualize the vocal cords by indirect mirror laryngoscopy before operation.

Technique of Operation (Figs. 699 to 708)

With adequate preoperative preparation the patient's basal metabolic rate will be normal, and the anesthesia problem in patients with hyperthyroidism is little different from that in patients with nontoxic goiter or other cervical conditions requiring operation. General anesthesia using an endotracheal tube is preferable in most instances. *Cyclopropane, because of the possible cardiac irritant effect, is to be avoided.*

The patient is placed in an inclined position on the table with the head lowered slightly to increase the prominence of the neck. This may be accomplished by placing a thin pillow high beneath the shoulders. Rotation of the head is avoided to prevent distortion of the neck incision. A low collar incision is made approximately 2.5 cm. above the inner ends of the clavicles. With large goiters, the incision is made somewhat higher. After healing, the scar should cross the suprasternal notch. The platysma muscle is divided, exposing the deep fascia and margins of the sternocleidomastoid muscles. The upper flap, which includes the skin, superficial fascia and platysma muscle, is easily separated upward from the deep fascia by blunt and sharp dissection as high as the thyroid notch. Gauze over the fingers or the knife handle may be used for blunt dissection. The lower flap is freed to the suprasternal notch. Injury to the anterior jugular veins is avoided when possible. Air embolism may result if large veins are opened. All bleeding vessels are ligated to clear the field.



FIGURE 699. Technique of thyroidectomy. Collar incision about 2.5 cm. above the suprasternal notch Incision should be placed somewhat higher in patients with large goiters to prevent the scar extending below the inner ends of the clavicles. (Guthrie and Brown: Surg., Gynec. & Obst., Vol 68. By permission of Surgery, Gynecology and Obstetrics)

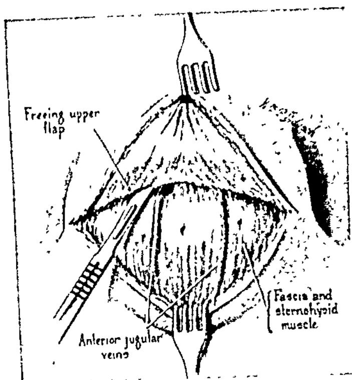


FIGURE 700. Technique of thyroidectomy (*continued*). Sharp and blunt dissection to separate the skin and platysma muscle from the fascia and muscles of the neck. (Guthrie and Brown: Surg., Gynec. & Obst., Vol. 68 By permission of Surgery, Gynecology and Obstetrics)

A midline vertical incision from the thyroid notch to the suprasternal notch exposes the isthmus of the thyroid. The sternohyoid and sternothyroid muscles are separated from the thyroid lobes by blunt and sharp dissection and retracted laterally. Retraction is made on one side at a time as the dissection proceeds. This usually affords sufficient exposure. If the goiter is large or the upper pole is high, the muscles may be divided high on each side to increase exposure and minimize traction to free the gland. The anterior jugular veins should be freed and doubly ligated before the muscles are severed.

As the first step in freeing the thyroid, the suspensory ligament, fascia and pyramidal lobe (when present) are divided, exposing the median margin of the upper poles, the upper margin of the isthmus, and the upper tracheal rings. Two or three vessels

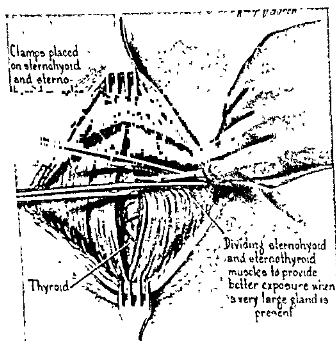


FIGURE 701 Technique of thyroidectomy (*continued*). To obtain adequate exposure, the sternothyroid and sternohyoid muscles may be divided high. This step is not necessary in many cases. (Guthrie and Brown: Surg., Gynec. & Obst., Vol. 68. By permission of Surgery, Gynecology and Obstetrics.)

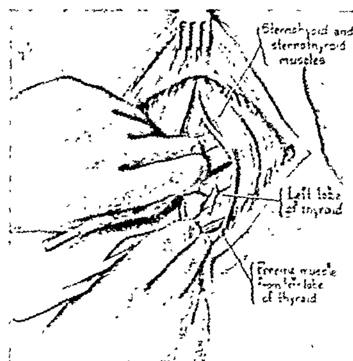


FIGURE 702. Technique of thyroidectomy (*continued*). The ribbon muscles are completely freed from the surface of the thyroid by sharp and blunt dissection. (Guthrie and Brown: Surg., Gynec. & Obst., Vol. 68. *By permission* of Surgery, Gynecology and Obstetrics.)

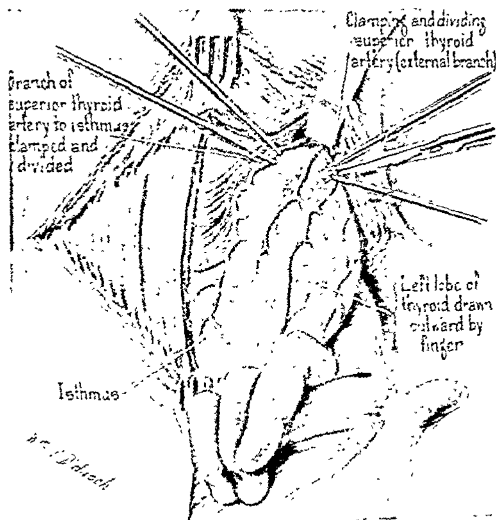


FIGURE 703. Technique of thyroidectomy (*continued*). Branches of the superior thyroid artery and vein are clamped and divided as the upper pole is dissected free. (Guthrie and Brown: Surg., Gynec. & Obst., Vol. 68. *By permission of Surgery, Gynecology and Obstetrics.*)

usually require ligation. If the goiter is large and disturbed breathing is likely to be encountered during the operation, the isthmus is divided before freeing the lateral lobes. This is not usually necessary. One upper pole is drawn gently downward with Lahey clamps or other traction forceps (a rake retractor may be used). By retracting the muscles laterally and upward and the thyroid downward and inward, branches of the superior thyroid artery and vein may be exposed by blunt dissection. These vessels are divided between clamps, leaving sufficient pedicle above to make ligation easy and avoid deep retraction of vessels if they should escape from the forceps. The severed vessels are separated from the gland with the capsule as the upper pole is drawn downward. As other branches of the superior thyroid vessels are exposed, they are clamped and divided until the pole is entirely free. All dissection should be made toward the gland to avoid injury to the laryngeal nerves where they enter the larynx medial to the upper pole. As soon as the upper pole is free, all vessels should be securely ligated before one proceeds further with the dissection.

The lateral portion of the lobe and the lower pole are next dissected free from the thyroid capsule. The median vein is clamped and severed. It serves as a good guide

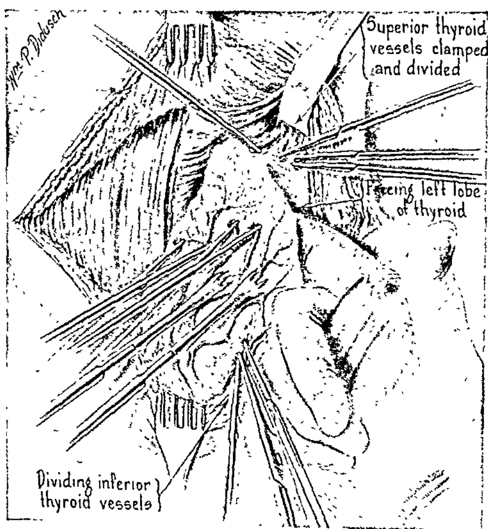


FIGURE 704. Technique of thyroidectomy (*continued*). Upper pole is mobilized by gentle traction and blunt and sharp dissection as the vessels are clamped and divided. All dissection is made toward the gland to prevent injury to the laryngeal nerves. Inferior thyroid vessels divided near the gland. (Guthrie and Brown: Surg., Gynec. & Obst., Vol. 68. By permission of Surgery, Gynecology and Obstetrics.)

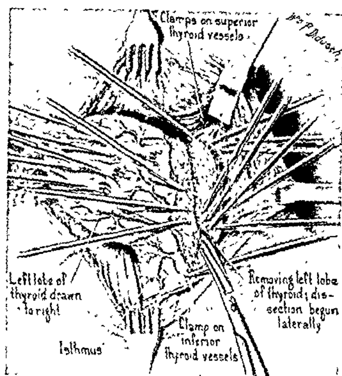


FIGURE 705. Technique of thyroidectomy (*continued*). Lateral dissection inside capsule to show approximate quantity of thyroid tissue to be left in situ (Guthrie and Brown: Surg., Gynec. & Obst., Vol. 68 By permission of Surgery, Gynecology and Obstetrics.)

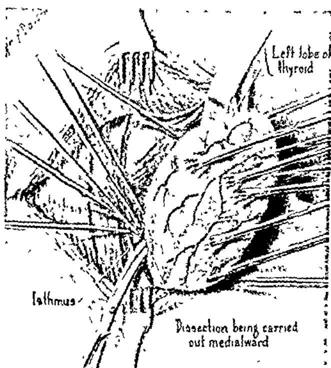


FIGURE 706. Technique of thyroidectomy (*continued*). The isthmus is divided, and dissection is made outward from the trachea. A thin remnant of the posterior capsule is left attached to the lateral wall of the trachea. (Guthrie and Brown; Surg , Gynec. & Obst , Vol. 68 By permission of Surgery, Gynecology and Obstetrics.)

to the capsule extending behind the gland. All vessels along the lateral margin and at the lower pole are clamped within the capsule and severed. By clamping vessels close to the gland and making all dissection within the capsule, injury to the recurrent laryngeal nerve and parathyroid glands is prevented.

After separating the capsule with its vessels from the posterolateral margin and lower pole, the isthmus is divided, and dissection is directed outward from the trachea as the lobe is lifted. Each vessel is identified and clamped as the dissection proceeds, directing the tips of the hemostats toward the gland rather than toward the trachea. As the lobe is removed, a thin portion of thyroid tissue is left attached to the posterior capsule to cover the sulcus between the trachea and esophagus. All vessels are care-

fully ligated. Two to four clamps may be left on the lateral margins of the capsule for identification purposes when the capsule is sutured later. The capsule is closed with interrupted sutures.

This completes one half of the operation. At this point the operation may be terminated if the patient is not doing well. If the operation is to be completed, the opposite lobe is removed in the same manner as the first.

If the anterior muscles have been divided, the severed ends are carefully approximated with interrupted or mattress sutures extending through the deep fascia. The sternothyroid is closed over the trachea. The sternohyoid and deep fascia are closed as a separate layer. The platysma is sutured carefully to prevent adhesions

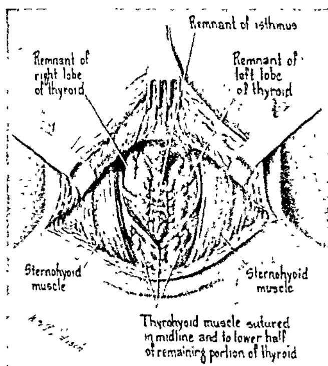


FIGURE 707. Technique of thyroidectomy (*continued*). Remnants of thyroid lobes sutured to sides of trachea. Sternothyroid muscles closed over thyroid remnants. (Guthrie and Brown· Surg, Gynec. & Obst, Vol. 68 By permission of Surgery, Gynecology and Obstetrics.)

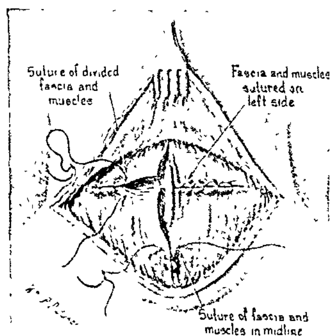


FIGURE 708 Technique of thyroidectomy (*concluded*). Divided ribbon muscles and fascia are carefully united with interrupted or mattress sutures Muscle and fascia closed with interrupted sutures in midline. The platysma muscle is closed with interrupted sutures and the skin with Michel clips or mattress sutures placed near the wound margins. If drain is used, it should emerge lateral to the midline (Guthrie and Brown· Surg., Gynec & Obst., Vol. 68 By permission of Surgery, Gynecology and Obstetrics)

between the skin and deeper neck muscles. Interrupted sutures are used throughout. The skin is closed with small mattress sutures of fine silk or with metal clips.

Drainage is used if there is any oozing or if the goiter is large, leaving considerable dead space, but otherwise it is not necessary. If a drain is used, it should emerge lateral to the midline. Drains are removed in twenty-four to forty-eight hours. Skin stitches are removed, half on the third and half on the fourth postoperative day.

ADENOMA OF THE THYROID GLAND

General Considerations

Although much has been written about the significance of the so-called solitary thyroid adenoma, considerable controversy still exists concerning this matter. The development of a carcinoma of the thyroid from a pre-existing adenoma is difficult to prove; however, there is a great deal of evidence to support the concept that thyroid carcinoma originates in pre-existing adenomas of the gland. There can be no controversy concerning the fact that the only conceivable method to determine the nature of an isolated thyroid nodule is surgical removal and pathologic study.

There is general agreement among surgeons that solitary adenomas should be removed because of the danger of malignancy. However, the exact method of removal as well as the preferable course of action if the nodule is found to be malignant remains the subject of considerable controversy. While Lahey advocated local enucleation of the discrete tumor, many surgeons believe that such a procedure may lead to seeding and secondary spread should the nodule be malignant and advocate removal of an ample margin of apparently normal thyroid tissue about the nodule. This usually involves subtotal removal of the lobe on the involved side and a portion of the isthmus. If the nodule is located in the posterior portion of the lobe, total lobectomy of the lobe containing the nodule may be indicated.

Technique of Lobectomy for Adenoma (Figs. 709, 710)

If the adenoma is large, the anterior muscles should be divided high so as to preserve the nerve supply. The upper pole of the involved lobe is dissected out with sharp and blunt dissection, thus permitting the superior thyroid artery and vein to be doubly ligated and divided. By retracting the thyroid lobe medially, the middle thyroid vein and inferior thyroid artery can be exposed. These are isolated, ligated and divided. With the gland further rotated, identification of the recurrent laryngeal nerve and parathyroids is simplified. Subtotal lobectomy can then be carried out by placing clamps from the periphery and dividing the gland tissue with a knife. In this fashion the nodule with a surrounding portion of normal thyroid gland is removed. Bleeding is then controlled by ligation of the previously placed clamps. A few suture ligatures may be inserted if troublesome bleeding points persist. After careful checking for hemostasis, the divided strap muscles are united by mattress sutures and the midline closed with interrupted sutures. The platysma muscles are then approximated with interrupted fine sutures and the skin margins approximated with Michel clips. If the adenoma is of considerable size, leaving dead space, or if oozing persists, a

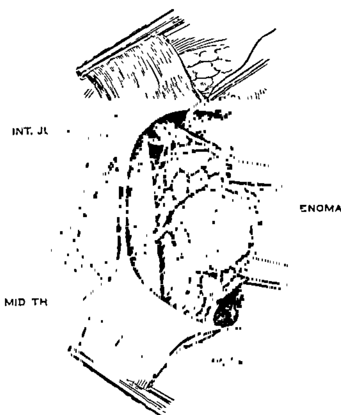


FIGURE 709. Thyroid lobectomy for adenoma The strap muscles have been divided, and the superior thyroid vessels are isolated and ligated before division. The middle thyroid vein is identified and ligated (B. Colcock: S. Clin North America, Vol. 36)



FIGURE 710. Thyroid lobectomy for adenoma (*concluded*) The superior pole and middle thyroid vein have been ligated and divided, thus permitting the entire lobe to be rotated medially. In this fashion the recurrent laryngeal nerve, the inferior thyroid artery and parathyroid glands can be carefully identified. (B Colcock S. Clin. North America, Vol. 36.)

rubber tissue drain is brought out the lateral margin of the incision, to be removed in twenty-four hours; however, in most instances drainage is not necessary.

Technique of Excision of Adenoma (Figs. 711, 712, 713)

The gland is exposed as described in thyroidectomy. If the adenoma is large, the anterior muscles should be divided.

The compressed thyroid tissue at the upper and lower poles is grasped with

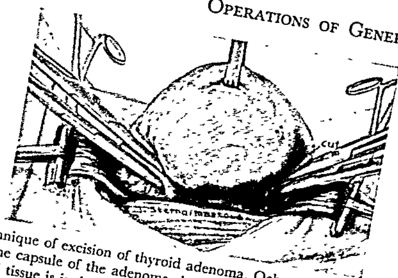


FIGURE 711. Technique of excision of thyroid adenoma. Ochsner clamps are applied above and below the adenoma. The capsule of the adenoma should not be included in the grasp of the clamps. The compressed thyroid tissue is incised until the capsule of the adenoma is exposed. The adenoma is then easily enucleated (Lahey: Ann. Surg., Vol. 86, J. B. Lippincott Company.)

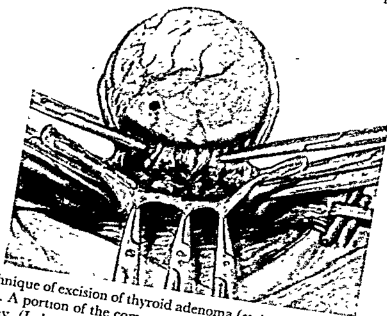


FIGURE 712. Technique of excision of thyroid adenoma (*continued*). The adenoma has been partially enucleated and rotated. A portion of the compressed thyroid tissue containing vessels is clamped before the adenoma is cut away (Lahey: Ann. Surg, Vol 86, J. B. Lippincott Company.)

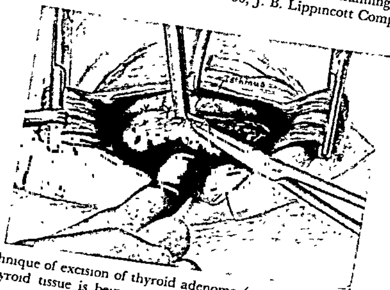


FIGURE 713 Technique of excision of thyroid adenoma (*concluded*). All vessels have been ligated, and the compressed thyroid tissue is being sutured. (Lahey Ann. Surg, Vol. 86, J. B. Lippincott Company.)

hemostats near the adenoma, avoiding the posterior gland capsule to protect the parathyroids and the recurrent laryngeal nerve. With these two points anchored, the thin overlying thyroid tissue is opened down to the capsule of the adenoma. By following the wall of the adenoma as a line of cleavage, the tumor is easily separated from the compressed thyroid substance. Bleeding vessels are grasped as the dissection proceeds. Any excess of the thin compressed thyroid is cut away, and the remainder is sutured after control of all bleeding by ligatures. To avoid injury to the recurrent laryngeal nerve, Goetsch recommends that large adenomatous goiters be removed by dissection from the tracheal side by incising the capsule adjoining the trachea and rolling the adenomatous mass laterally.

Multiple adenomas may be enucleated as described. If the patient is very toxic, and there is a suspicion that the thyroid gland is hyperplastic, a subtotal thyroidectomy should be done.

The anterior portion of the compressed gland, which has formed a capsule for the adenomas, is removed. The posterior portion is sutured to make a neat closure of the remaining gland tissue. Drainage is not necessary unless there is considerable space left by the removal of a large adenoma.

OPERATION FOR INTRATHORACIC GOITER

General Considerations

Goiters may be partially or completely intrathoracic. When directly in the midline, they are located anteriorly in the upper chest in front of and above the large vessels and in front of or to one side of the trachea. The trachea may be pushed to one side and flattened. The sternum lies in front and the arch of the aorta below. When lying to either side of the midline in the upper thorax, they are in relation to the vertebral column and esophagus behind, to the trachea medially, to the apical pleura laterally and to the carotid, innominate or subclavian arteries and veins anteriorly.

Dangers and Safeguards

There is some danger that a small intrathoracic goiter may be overlooked at operation unless the upper thorax is carefully explored. An x-ray film of the chest should be taken in all cases of large adenomatous goiters to avoid this error. Large goiters may be difficult to remove through the normal upper thoracic aperture. In rare instances division of the sternum or disarticulation of the clavicle may be necessary to deliver a large goiter. Evisceration of the tumor to reduce the size is the better procedure. All fragments of tissue must be removed from the remaining cavity to prevent infection. By dissecting close to the adenoma as gentle traction is exerted from above, injury to the pleura and vessels is avoided. The vessels supplying the goiter become more accessible as the mass is lifted into the neck, making control of bleeding relatively easy. Calcification may make delivery more difficult and, if adherent, cause excessive bleeding. Pressure on the trachea may be disturbing during the delivery of the tumor. An anesthetic administered through a rigid intratracheal tube will avoid this difficulty.

Technique of Operation

Intratracheal anesthesia is used. A low collar type of incision is made with exposure as described above for thyroidectomy. The sternohyoid and sternothyroid muscles are divided high and reflected.

The superior pole of the thyroid is freed as the first step in removing the goiter. This step permits mobilization of the lobe and controls more of the gland blood supply. The blood supply to an intrathoracic goiter all comes from above and should be controlled before dissection is begun for removal of the tumor. To free the intrathoracic mass, the finger is gently inserted along its wall to separate the surrounding connective tissue. Gentle lifting with the finger may dislocate the growth. Lahey states that it is much easier and safer to pass the finger into the mediastinum from the rear rather than along the front of the tumor. On the posterior surface below the middle thyroid veins there is a distinct line of cleavage, and no veins of importance are present that may be torn.

Combined gentle traction on the tumor with the finger pressure from below aids delivery. Traction from above prevents the tendency of the tumor to widen from pressure below. All dissection should be made against the capsule of the tumor.

After delivery of the mass into the neck the cavity is packed with moist gauze while the thyroidectomy is completed.

Unless there is calcification or unusual adhesions along the trachea, there is little danger to the recurrent laryngeal nerves if all dissection is made near the tumor capsule. There is usually a posterior shell of thyroid tissue present which protects the nerves and parathyroids. The capsule of the gland is sutured. All bleeding points are carefully ligated to prevent the formation of hematomas. A drain of the cigarette type is placed in the space left by removal of the tumor, to remain for a few days to prevent accumulation of blood and serum.

TOTAL THYROIDECTOMY

Technique of Operation

The position of the patient on the operating table and the exposure of the thyroid gland do not differ from the procedures used in other thyroidectomies. Danger of injury to the parathyroid glands and recurrent laryngeal nerves is greater than in subtotal thyroidectomy.

The suspensory ligament is divided, and the pyramidal lobe is separated, exposing the upper tracheal rings. The superior and inferior pole vessels are isolated, clamped, severed, and ligated close to the surface of the gland. The lateral vein is severed and ligated. The upper pole is carefully separated by blunt dissection near the gland to avoid injury to the nerves where they enter the larynx At the lower pole the recurrent laryngeal nerve can usually be identified passing between the branches of the inferior thyroid artery. The nerve is easily avoided when it is visualized. The isthmus is divided, and part of the dissection is made from within outward.

By making all dissections just within the thyroid capsule, the parathyroid glands may be avoided. They should be identified if possible as dissection proceeds. They are

small bodies about 4 by 6 mm. in size and have a pinkish or chocolate-brown color. The superior glands are usually located on the posterior surface of the thyroid on a level with the lower portion of the thyroid cartilage, and the inferior glands are beneath the inferior pole or in the nearby fat.

The remaining lobe is removed in the same manner as the first. It is more convenient for some surgeons to change sides for dissection of the second lobe.

After removal of the thyroid gland Cutler and Zollinger advise a careful search for any attached parathyroid glands. If a gland is found, it should be transplanted into the sternocleidomastoid muscle.

Wound closure is made as described elsewhere for subtotal thyroidectomy.

CARCINOMA OF THE THYROID

General Considerations

As in no other organ, primary carcinoma of the thyroid exhibits vast differences in biologic behavior and in histologic structure. Although several different pathologic classifications of thyroid carcinoma are in use today, it is generally agreed that the papillary carcinomas and malignant adenomas constitute from 60 to 75 per cent of thyroid malignancy. Because of the slow rate of growth of the primary lesion, as well as the tendency for metastases to remain localized and appear late, the extent of these lesions and indications for operation remain the subject of considerable controversy. Crile and others believe that lobectomy of the involved side combined with local excision of any palpable metastases in the cervical region constitutes adequate removal of these lesions. Others, such as Lahey and Cattell, believe that radical cervical dissection should be added to lobectomy on the involved side as a routine procedure. The question remains somewhat unsettled, and decision concerning the extent of cervical dissection to be carried out must be made on the basis of the histologic appearance of the primary tumor as well as the age and clinical status of the patient.

The treatment of anaplastic carcinoma of the thyroid is unsatisfactory. A combination of operation and radiation therapy is the treatment of choice in most cases.

Technique of Thyroid Lobectomy and Modified Neck Dissection (Fig. 714)

Incision and exposure are carried out as described for operation for adenoma. When the diagnosis of papillary carcinoma is made by gross or histologic examination, and when palpable cervical nodes are present, either preoperatively or by examination along the jugular region, modified radical neck dissection is indicated. The collar incision is extended far laterally and superiorly along the sternocleidomastoid muscle, as illustrated. Flaps containing skin and the platysma muscle are elevated. The sternocleidomastoid muscle is transected 3 cm. above the clavicle and reflected superiorly and inferiorly. If there is evidence of invasion of the muscle, the entire sternocleidomastoid is sacrificed as in the usual radical neck dissection. The superior thyroid vessels are isolated and doubly ligated. The inferior thyroid artery is then ligated close to its point of origin and divided. The internal jugular vein is then dissected just above the clavicle, doubly ligated and divided. A block dissection is then carried upward to include the strap muscles, the involved lobe of the thyroid and thyroid isthmus as

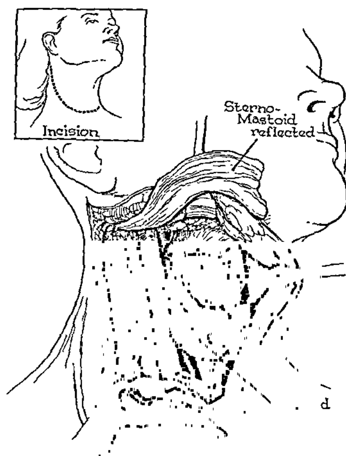


FIGURE 714. Technique of thyroid lobectomy and modified neck dissection. When the presence of carcinoma has been determined, the usual collar incision is extended laterally and posteriorly along the sternocleidomastoid muscle, as shown in the inset. Flaps containing the platysma muscle are developed, and the sternocleidomastoid muscle is divided 3 cm. above the clavicular attachment. This permits removal en bloc of the strap muscles, the involved lobe of the thyroid and thyroid isthmus, the internal jugular vein and all adjacent lymph-bearing tissues. The sternocleidomastoid muscle is then reapproximated (C Eckert and L T. Byars: Ann. Surg., Vol. 136.)

well as the internal jugular vein and the adjacent lymph-bearing tissue. The recurrent laryngeal nerve is isolated and preserved. The submaxillary and parotid glands are not disturbed. The internal jugular vein is ligated and divided just above the posterior belly of the digastric muscle. The area is then checked for hemostasis and the wound irrigated with saline solution. The cut ends of the sternocleidomastoid muscle are reapproximated with mattress sutures. A Penrose drain is placed in the area and the platysma approximated with interrupted sutures. The skin edges are approximated with interrupted sutures and a firm pressure bandage applied.

OPERATIONS UPON THE PARATHYROID GLANDS

General Considerations

The chief indication for operation upon the parathyroid bodies is hyperparathyroidism. Carcinoma of the parathyroid gland is rare. In 1948 Norris recorded fifteen authentic cases. The treatment of choice is complete surgical removal. Transplantation of a parathyroid may rarely be indicated when it is removed by accident during thyroidectomy.

There are usually four parathyroids, although there may be as many as six. The

common location is behind the thyroid (Fig. 697). They may rarely be found in folds of the gland on the anterior or lateral surface or entirely separated from the thyroid in the lower anterior region of the neck, behind the trachea, or even in the upper mediastinum.

Dangers and Safeguards

It is evident from the possible anatomic variations of the parathyroids that a careful search for adenomas, and careful dissection after they have been found, are necessary to avoid error. The normal and adenomatous parathyroids must be distinguished from adenomas of the thyroid and lymph nodes. The normal parathyroids are pinkish or chocolate-brown and are usually oblong or somewhat stellate in appearance. During dissection the same precautions should be used as in thyroidectomy. There is definite danger of injury to the recurrent laryngeal nerves. Bleeding and the formation of hematomas obscure the field of operation and make identification of adenomas very difficult. Tetany may follow the removal of an adenoma, requiring postoperative treatment with dihydrotachysterol and calcium. In the search for or removal of an adenoma the blood supply to the normal parathyroids must not be damaged. Many patients with parathyroid tumors are in poor physical condition; therefore an extended operation would be hazardous.

Technique of Parathyroidectomy (Churchill and Cope) (Figs. 715 to 718)

General anesthesia is usually advisable to avoid motion and interference with delicate dissection. The position of the patient on the table is the same as that in thyroidectomy.

A wide collar incision is made. The pretracheal muscles and middle cervical fascia are dissected from the surface of the thyroid and sectioned. The thyroid is inspected and palpated for evidence of tumor behind it or within its substance. The



FIGURE 715 Excision of parathyroid tumor Tumor exposed by dividing muscles and elevating lobe of thyroid. (Churchill and Cope Surg, Gynec & Obst, Vol 58. By permission of Surgery, Gynecology and Obstetrics.)

carotid sheaths are identified, and the lateral thyroid veins are cut and ligated. These steps permit examination of the posterolateral surfaces of the thyroid and identification of the inferior thyroid arteries and recurrent laryngeal nerves. Both sides are carefully investigated. In most cases the blood supply arises from the inferior thyroid artery, and an adenoma may be found by tracing the vascular supply from this source even when the tumor is located in the mediastinum.

The trachea and esophagus are then exposed, and the dissection is carried upward to the larynx and downward into the superior mediastinum. The posterior mediastinum behind the trachea and esophagus is searched with the finger. Structures as low as the primary bronchus may be palpated. The structures should be palpated between fingers introduced into both sides of the posterior mediastinum. Substernal



FIGURE 716. Excision of parathyroid tumor (*continued*). Tumor is situated between the trachea and esophagus posterior to the recurrent laryngeal nerve. (Churchill and Cope: Surg., Gynec. & Obst., Vol. 58. By permission of Surgery, Gynecology and Obstetrics)

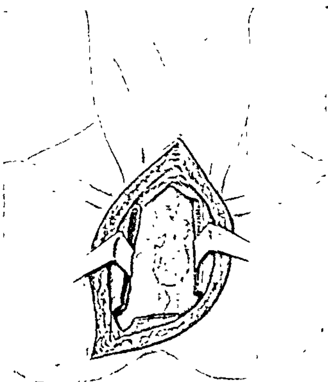


FIGURE 717. Excision of parathyroid tumor (*continued*). A retrosternal tumor is exposed by splitting the sternum and retracting the halves. (Churchill and Cope: Surg., Gynec. & Obst., Vol. 58. By permission of Surgery, Gynecology and Obstetrics)

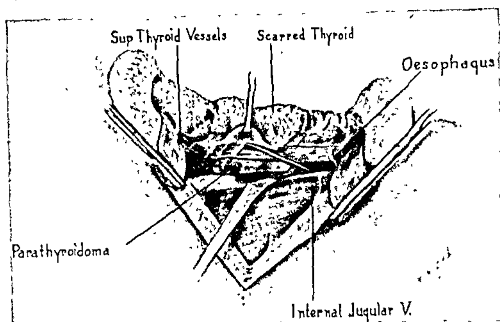


FIGURE 718. Excision of parathyroid tumor (*concluded*). The tumor lies behind the esophagus, where is may easily be overlooked at operation (Churchill and Cope: Surg., Gynec. & Obst., Vol. 58. By permission of Surgery, Gynecology and Obstetrics.)

parathyroid tumors can be delivered into the operative field by gentle traction. Splitting of the sternum for exposure will rarely be necessary.

If no tumor is found, removal of normal parathyroids or interference with their blood supply is contraindicated, although small pieces for biopsy should be taken. The tumor may be found at a later operation.

Nodular goiters are not infrequently present with parathyroid tumors. This makes identification of the parathyroids more difficult. Resection of the thyroid should be postponed when possible until the search for parathyroids has been completed

Secondary operations are always more difficult than primary because of scar tissue; therefore careful and painstaking exploration of the entire cervical region should be carried out at the first procedure.

When the operator is convinced that a tumor is not present in the cervical region, then exploration of the upper mediastinum through a sternum-splitting incision must be carried out. This may be done as a continuation of the cervical operation or, better, may be done as a second procedure.

The wound is closed as in thyroidectomy. Drainage is usually not necessary.

OPERATIONS UPON THE ADRENALS

General Considerations

The adrenal glands, consisting of a medullary portion derived from neurogenic ectodermal tissue, and a cortical portion derived from primitive celomic epithelium, are in reality two unrelated organs, each having an independent endocrine function. A better understanding of the complex physiology and biochemistry of these organs during recent years has clarified considerably the indications for operation on the

adrenal glands and has made it possible to provide replacement and supportive treatment to the patient during and after operation with a low operative risk.

Tumors of the adrenal medulla may be nonendocrine tumors of neurogenic origin, such as the neuroblastomas more commonly seen in infancy and childhood, or may be of the endocrine type *such as the pheochromocytomas, which* produce both epinephrine and norepinephrine and cause symptoms similar to those produced by the injection of epinephrine.

The adrenal cortex is an extremely complex endocrine organ elaborating numerous steroid hormones having widespread and diverse physiologic effects. Tumors of the cortex may be nonfunctioning, but more often produce dramatic changes either of the Cushing's syndrome type, in which the metabolic changes predominate, or of the adrenogenital syndrome type, in which the predominant changes are those associated with secondary sex characteristics. In many instances a combination of the two basic types of changes will be seen in a patient having an adrenal cortical tumor. Identical changes may result from hyperplasia of the adrenals without tumor.

Since replacement therapy now makes it possible to do bilateral total adrenalectomy, the beneficial effects of such a procedure for endocrine-dependent tumors such as carcinoma of the breast is being investigated. In addition, the possible place of such a procedure in the therapy of essential hypertension is being studied.

When the diagnosis of adrenal disease is made or strongly suspected, whether it be of the cortex or the medulla, it is important to know if possible whether there is a tumor present and if so which adrenal is involved. The medullary pheochromocytomas occur bilaterally in approximately 10 per cent of cases, and an additional 10 per cent may occur in an extra-adrenal location along the paravertebral sympathetic chain. Urinary pyelography and presacral oxygen insufflation, either alone or combined, are often of value in the localization of adrenal tumors.

The adrenals may be approached transabdominally, transthoracically or retroperitoneally. No single approach is suitable for all types of lesions which may be encountered, and even with the best exposure removal of adrenal tumors may be difficult. The operative approach must be planned to best accomplish the desired results in the individual patient. In many instances both glands must be exposed.

Special preoperative preparation as well as careful management during and after the operative procedure is necessary. Manipulation of pheochrome tumors during operation may precipitate dangerous hypertensive crises, and after removal of a tumor the blood pressure may fall precipitously to shock levels. The use of one of the epinephrine competitors such as Regitine may be of value in avoiding hypertensive crises. The drop in blood pressure which occurs after removal of the tumor can be controlled by the administration of norepinephrine. When operating upon patients with diseases of the adrenal cortex, care must be taken to avoid the occurrence of severe electrolyte disturbances. These can be avoided by preoperative use of cortisone or hydrocortisone as well as the use of these substances during and after operation. Supplemental sodium may be necessary in patients with Cushing's syndrome caused by tumor; the contralateral gland may be markedly suppressed, so that extreme care must be taken to avoid adrenal insufficiency following removal of the tumor.

Approach to and removal of the left adrenal are technically less difficult than the right. The right adrenal lies near the vena cava and has a short central vein which

empties directly into the cava. On the left the central vein empties into the renal vein and is more accessible.

Technique of Adrenalectomy (Bilateral Subdiaphragmatic Retroperitoneal Approach) (Fig. 719)

General endotracheal anesthesia is preferred. The patient is placed in the prone position and the table broken in the middle to produce flexion of the hips. A curved oblique incision is made over the course of the twelfth rib. After incising the skin and fat, the latissimus dorsi muscle is exposed and divided. The twelfth rib is thus exposed and the entire rib removed subperiosteally. The serratus posticus inferior muscle may be divided medially to get better exposure. Incision of the posterior periosteum then exposes the lower reflection of the pleura, which is swept upward, care being taken not to enter the pleural space. If additional exposure is required, the incision can be extended upward and the eleventh or tenth rib divided. The retroperitoneal fat is pushed aside, and Gerota's fascia is incised to expose the kidney. The adrenal lies immediately above and near the upper pole of the kidney. Exposure can be improved by retracting the kidney downward with the fingers or a broad retractor. By careful dissection the adrenal is freed of surrounding fat, exposing the vessels, which can be clamped and controlled with cautery or ligature. If exposure of the opposite gland is necessary, identical incision and exposure is made on the opposite side. The wound is then closed in layers with interrupted silk. If hemostasis has been complete, drainage is not necessary.

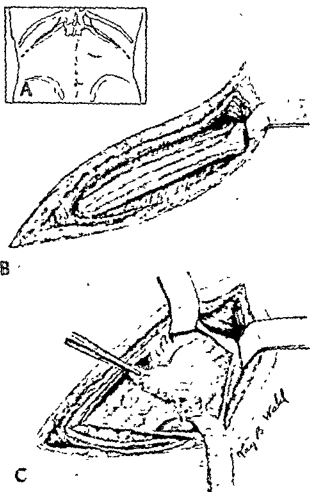


FIGURE 719. Bilateral adrenalectomy, using subdiaphragmatic, retroperitoneal approach. *A*, Site of incisions over the twelfth ribs The patient is placed on his abdomen in a slightly flexed position *B*, The twelfth rib is exposed and removed subperiosteally. *C*, Gerota's fascia has been incised and the kidney retracted downward to expose the adrenal gland.

OPERATIONS UPON THE THYMUS

General Considerations

Operations upon the thymus have been infrequent. The chief indications are tumors, both benign and malignant, and myasthenia gravis. The results of operations upon the thymus for malignant tumors have been unsatisfactory. Radiotherapy has also been disappointing. Results of thymectomy for benign tumors and myasthenia gravis have been encouraging. Blalock has stated that additional time, experience and investigation will be necessary before the exact role of thymectomy in the treatment of myasthenia gravis can be determined.

Careful preoperative and postoperative care is necessary for the patient with myasthenia gravis. The patient should have several days of rest before operation, with adequate doses of neostigmine methylsulfate. All drugs of the curare type should be avoided. *Since patients having this disease are more prone to have respiratory infections,* the prophylactic use of a broad-spectrum antibiotic is indicated. In female patients operation should not be done during menstruation. Thirty minutes before the anesthetic is started, 1.5 to 2.5 mg. of Prostigmin, 0.6 mg. of atropine and 10 mg.

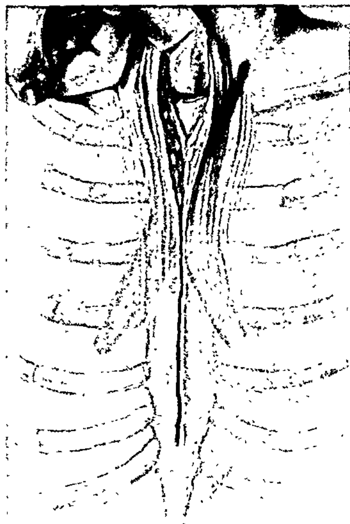


FIGURE 720. Thymectomy A midline sternum-splitting incision is used from above the manubrium to the xiphoid The areolar tissue is separated from the posterior margin of the sternum by the finger preparatory to division with a sternum-splitting knife (O T. Clagett, L M Eaton and R P Glover Surgery, Vol 26)

of morphine are given subcutaneously. At the end of the operation 1 to 1.5 mg. of Prostigmin methylsulfate and 0.6 mg. of atropine are given every two hours for the first postoperative day. Prostigmin bromide may then be given by mouth in 30- to 45-mg. doses every two or three hours for two or three days. The drug should usually not be discontinued entirely for two or three weeks. Atropine is given to prevent bronchial spasm induced by the Prostigmin.

Clagett and Eaton recommend that every patient be placed in an oxygen tent immediately after operation. These authors also advise that a Drinker type of respirator be available for use if the patient shows evidence of exhaustion or respiratory difficulty.

Technique of Thymectomy (Clagett) (Figs. 720 to 723)

General endotracheal anesthesia is necessary. A vertical midline incision is made from the manubrium to just above the xiphoid. If one wishes to avoid a scar directly over the bony sternum, the incision may be curved gently to one side of the sternum

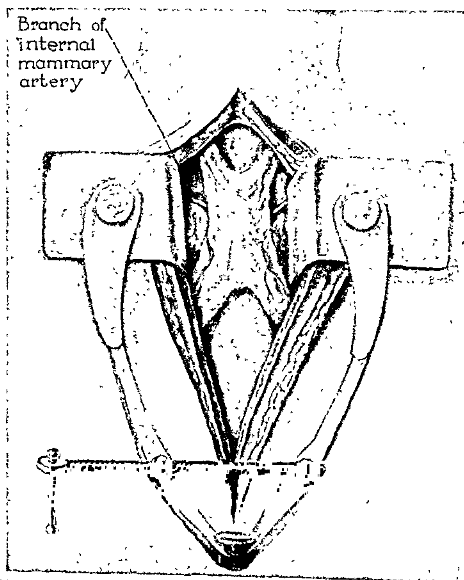


FIGURE 721. Thymectomy (*continued*) With the sternal edges retracted the more common location and configuration of the thymus are shown. The blood supply is derived from the inferior thyroid vessels and from branches of the internal mammary artery. (O. T. Clagett, L. M Eaton and R. P Glover: Surgery, Vol. 26.)

and a flap developed. The pretracheal fascia lying in the suprasternal notch is divided and the finger inserted behind the manubrium, pushing the soft tissues away as the finger advances. The sternum is then split from the manubrium downward, using a Lebsche sternal knife or shears. A self-retaining retractor is placed in the incision and the edges of the split sternum separated. This gives adequate exposure of the entire upper anterior mediastinum. The thymus gland may be obscured by fat and areolar tissue, but can be recognized by its pinkish gray color and granular surface. The gland is usually bilobed, joining broadly in the midline over the innominate vein, each lobe having superior and inferior projections. The blood supply is received from the inferior thyroid artery above and from branches of the internal mammary artery laterally. The venous drainage usually is into the innominate vein posteriorly. The gland is usually loosely encapsulated; however, it may be adherent to the pleura laterally.

Because of its friability, dissection must be done in a fashion to avoid tearing the gland. When the gland has been removed, the aorta, pulmonary artery and left innominate vein are visible. The split edges of the sternum are then approximated, and the fascia and periosteum on the anterior surface of the sternum are united with interrupted silk sutures. Subcutaneous tissues and skin are likewise approximated with

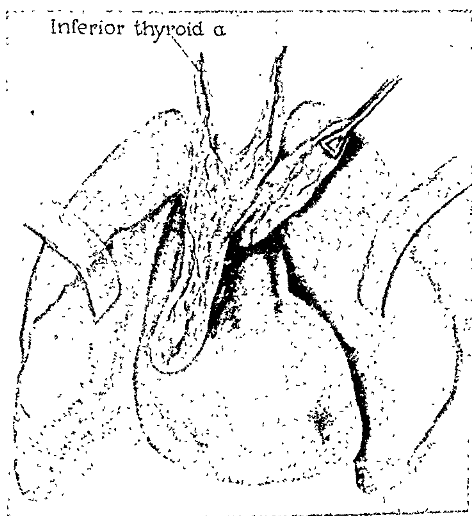


FIGURE 722 Thymectomy (*continued*) Illustrating the more usual size and location of the thymus gland The upper poles extend into the neck and the lower poles into the pericardium. *In certain* instances the thymus may be small and may be located in part or entirely behind the innominate vein. (O. T. *Clagett*, L. M. Eaton and R. P. Glover. Surgery, Vol 26)

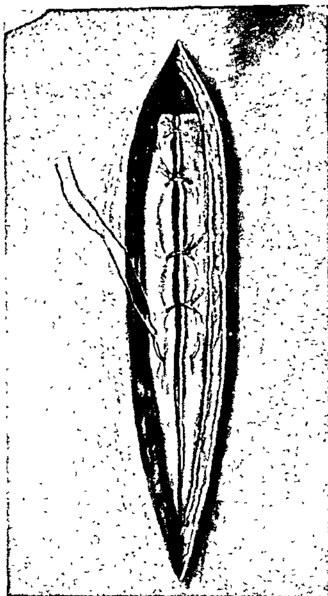


FIGURE 723. Thymectomy (*concluded*). When the gland has been removed and hemostasis ensured, the sternum is reapproximated, and sutures are placed in the periosteum and fascia The subcutaneous tissue and skin are then closed in the conventional manner. (O. T. Clagett, L. M. Eaton and R. P. Glover: Surgery, Vol. 26)

interrupted silk. If the pleura has been opened, the air in the pleural space should be aspirated with a catheter and the catheter removed as the last stitches are being tied. The thymus gland may vary considerably in size and may lie entirely or partly behind the innominate vein.

OPERATIONS UPON THE GONADS AND UPON ISLET TUMORS OF THE PANCREAS

Descriptions of these operations are included in other chapters.

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CHAPTER 19

Genitourinary System

OPERATIONS UPON THE PENIS

CIRCUMCISION

General Considerations

The most important *indication* for circumcision is phimosis. Uncleanliness resulting from redundant prepuce, recurrent attacks of balanoposthitis, venereal warts, herpes and enuresis have been considered good reasons for circumcision.

Many techniques for circumcision have been described. The single method described here is simple and efficient.

General anesthesia is usually advisable for babies and young children. Local anesthesia is usually suitable for youths and adults.

Dangers and Safeguards

Careless technique in doing a circumcision may result in the removal of too much or too little of the prepuce or imperfect healing. Enough of the prepuce should be retained to cover the corona. Bleeding vessels should be carefully ligated to prevent

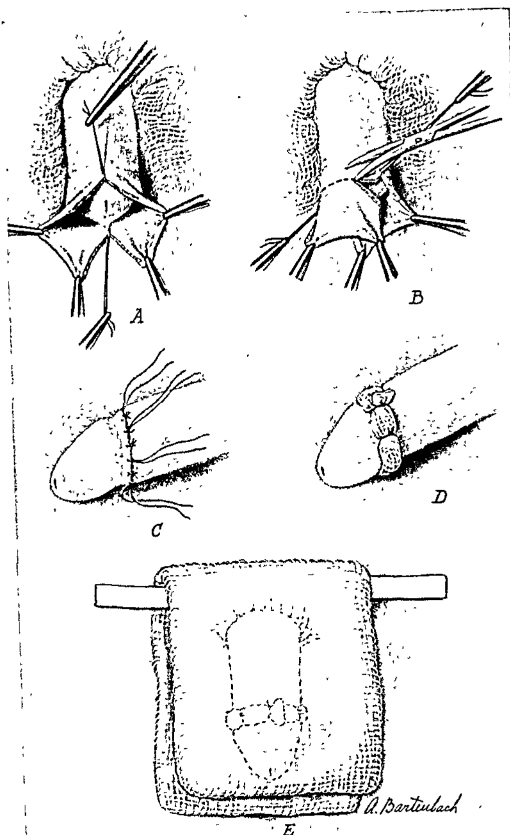


FIGURE 724. Technique of circumcision. *A*, Dorsal and ventral slits made in prepuce with traction sutures in place *B*, Lateral prepuce flaps are removed with scissors. *C*, Incision sutured Several sutures left long to tie on dressing. *D*, Circular dressing of petrolatum gauze tied in place. *E*, Penis passed through opening in gauze for additional dressing.

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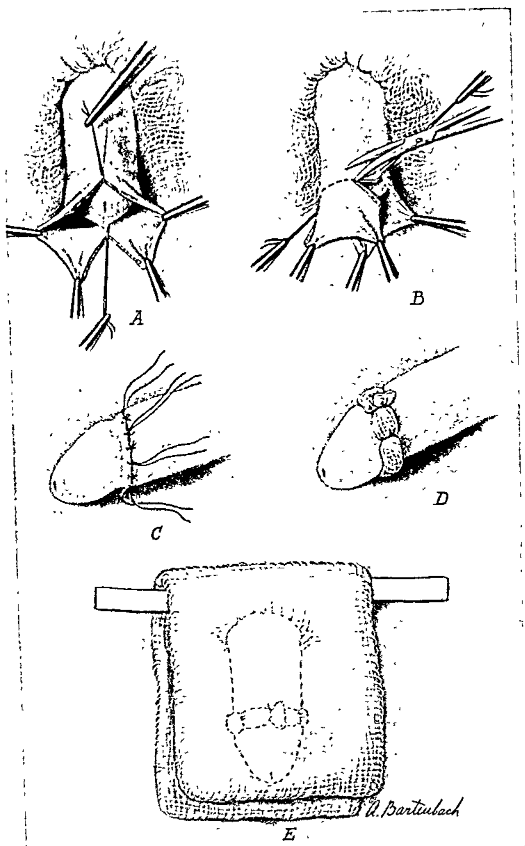


FIGURE 724 Technique of circumcision. *A*, Dorsal and ventral slits made in prepuce with traction sutures in place. *B*, Lateral prepuce flaps are removed with scissors. *C*, Incision sutured. Several sutures left long to tie on dressing *D*, Circular dressing of petrolatum gauze tied in place. *E*, Penis passed through opening in gauze for additional dressing.

the formation of hematomas. Infection is not common, but may result from faulty preoperative cleansing if active disease is present at the time of operation.

Technique of Operation (Fig. 724)

When possible, the prepuce should be retracted to separate adhesions to the glans. Adhesions may be separated with a small, smooth instrument or blunt-pointed scissors passed beneath the prepuce about the glans.

Four small Halsted mosquito clamps or Allis clamps are used for traction. A dorsal slit is first made with straight scissors to a point 0.5 cm. above the corona. A similar slit is made at the frenum, leaving about 0.75 cm. of the mucosa at this point. By placing traction on the corners of the two lateral flaps formed by the dorsal and ventral slits, the circumcision is completed with a curved pair of scissors by cutting away the flaps around the corona. Too much tension during this procedure may result in the removal of too much skin.

Traction sutures may be placed dorsally and ventrally either before or after the removal of the prepuce. Small vessels are carefully ligated with fine plain catgut. Three stitches in each side between the traction sutures are usually sufficient. The wound edges should be carefully approximated with very fine plain catgut placed close to the wound edges. All stitches are left long and, when suturing is complete, used to tie on a strip of petrolatum gauze for a dressing.

A flap of gauze with a hole in it for the penis makes a good dressing when attached above the pubes with adhesive.

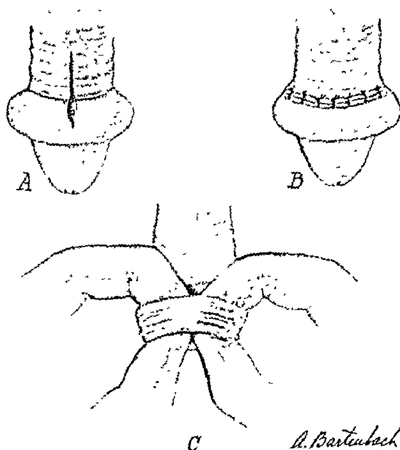


FIGURE 725 Operation for paraphimosis A, Incision made through constricting tissues. B, Transverse suture of wound to relieve constriction C, Method of reducing paraphimosis by gradual pressure on glans with thumbs and traction on edematous ring with fingers

The urethra is divided obliquely, or a short dorsal incision is made to prevent stricture.

Silk is used to close the wound. The skin left at the base of the penis is sutured over the stump of the corpora cavernosa, and the tip of the urethra is sutured to the skin.

A drain is placed in each groin through stab wounds, and a retention catheter is placed in the bladder.

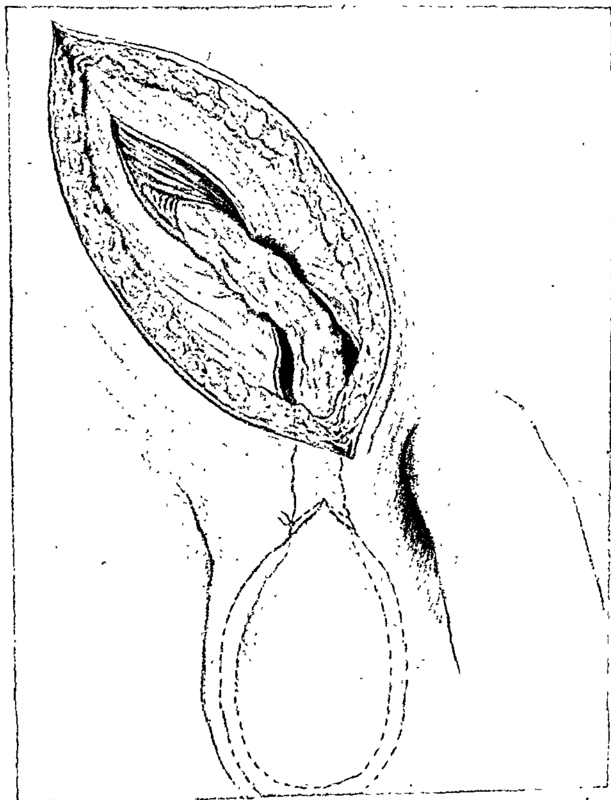


FIGURE 726. The Kondoleon principle of operation applied to elephantiasis of scrotum and penis. Spermatic cord transplanted beneath the skin Tunica vaginalis partially removed and sutured behind the cord, bringing testicle into contact with subcutaneous tissues.

TECHNIQUE OF OPERATION FOR ELEPHANTIASIS OF SCROTUM AND PENIS (FIG. 726)

The principle of the Kondoleon operation is applied. The scrotum and skin and subcutaneous tissues of the penis are drained by superficial lymphatics. The testicle, spermatic cord, and body and glans of the penis are drained by deep lymphatics. This operation removes as much as possible of the tissues drained by the superficial lymphatics and establishes a communication between the deep and superficial lymphatic vessels by transplanting the cord and testicle beneath the skin.

The scrotum is amputated, usually by a transverse elliptical incision. Since the testicles are not involved in the diseased tissues, they are usually found high within the anterior portion of the scrotum. The testicles are located and protected. Careful hemostasis is necessary to avoid interference with healing. The scrotal stump is sutured with interrupted silk sutures.

A hernia incision is made, and the testicle, with its cord up to the internal ring, is completely transplanted beneath the skin by incising the aponeurosis of the external oblique muscle and suturing it beneath the cord. The tunica vaginalis is cut away or stitched behind the testicle so that the testicle comes in contact with the subcutaneous tissues. The same technique is used for both sides. The skin is closed with interrupted sutures.

A circumcision may be done to remove a redundant prepuce a few weeks later when the edema is reduced to a minimum.

EXCISION OF INGUINAL LYMPH NODES

General Considerations

Bilateral excision of the inguinal lymphatic nodes is indicated as a part of the operation for malignancy of the external genitals, including carcinoma of the penis. In addition, groin dissection should be carried out in cases of carcinoma of the anus and perineum. Unilateral radical groin dissection may be indicated in primary malignancy involving the lower extremity, lower abdominal wall and buttocks. The major indication for this operation is melanoma or squamous cell carcinoma involving the areas which drain into the femoral, inguinal and deep iliac lymph nodes.

Technique of Radical Groin Dissection (Figs. 727, 728, 729)

The incision to be used and the extent to which flaps are developed depend on whether a unilateral or bilateral dissection is to be carried out. The incision for unilateral dissection begins approximately 2.5 cm. medial to the anterior superior iliac spine and extends downward in a curving fashion to terminate in the midthigh over Hunter's canal, as indicated in Figure 727, *A*. Skin flaps are then raised over the anterior thigh and lower abdomen as indicated, leaving a thin layer of underlying fat attached to the skin. Care should be taken not to extend the flaps too far beyond the extent of the underlying dissection

When bilateral dissection is to be done, a curved transverse incision extending from the anterior superior iliac spine and passing just above the symphysis is indi-

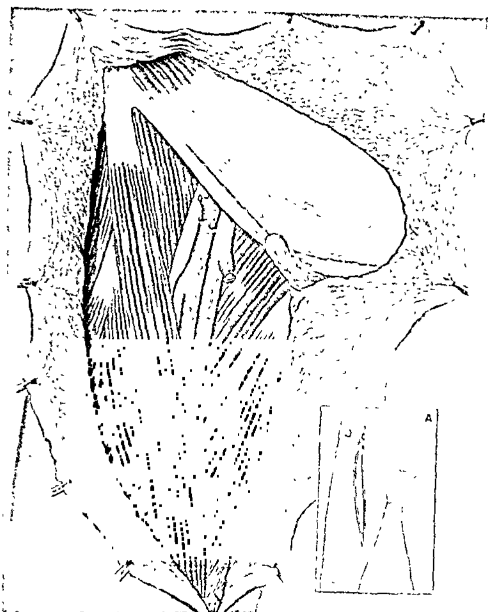


FIGURE 727 Radical groin dissection *A*, Incision for unilateral groin dissection, beginning medial to the anterior superior iliac spine and extending downward to the mid-thigh over Hunter's canal *The shaded area indicates the extent of the dissection. B,* The operative field is shown after completion of the femoral and inguinal node dissections The dotted line shows the incision in the external oblique fascia and rectus sheath (L S Gumport and H. W Meyer: Surgery, Vol. 38.)

cated, as in Figure 728, *B*. When operation is being done for lesions of the genitals, perineum and anus, the dissection does not have to be carried as far inferiorly on the thighs as when it is being done for lesions of the extremity.

When the skin flaps have been developed, the deeper lymphatic tissues are dissected from the underlying aponeurosis from above downward to the inguinal ligament. The dissection is then shifted to the lower region of the incision where the fat and lymphatic tissue are dissected from below upward. The greater saphenous vein is divided below. In addition to the saphenous vein, lymphatic tissue and fat, the fascia of the sartorius, iliacus, pectineus, adductor longus and rectus femoris muscles as well as the sheath of the femoral vein is removed. The vascular and nerve supply of the sartorius muscle is carefully preserved to be used as a covering for the femoral vessels. The tissue to be removed is dissected toward a point at the medial side of the femoral vein. The greater saphenous vein is then divided at its junction with the

femoral vein, and the superficial branches of the femoral artery are clamped, ligated and divided. Removal of this tissue should include the femoral and inguinal nodes and lymphatics.

The deep iliac node portion of the dissection is then done. The external oblique aponeurosis is divided from the external inguinal ring, extending obliquely lateral and parallel with the inguinal ligament. This incision is then carried medialward across the rectus sheath to the midline, as indicated in Figure 727. The underlying muscles, including the rectus, are divided down to the peritoneum, and the peritoneum is swept cephalad. The deep epigastric vessels are then ligated and divided, and all fat, areolar and lymphatic tissue is dissected from the external iliac vessels as high as the common iliac vessel. Care must be taken not to injure the ureter at this point. The dissection is then carried medialward as far as the obturator nerve. When the deep iliac node dissection is completed, the area is checked carefully for hemostasis. The rectus sheath is resutured, and the transversalis fascia is sutured to Cooper's ligament to reconstitute the floor of the inguinal canal. The space medial to the femoral vein

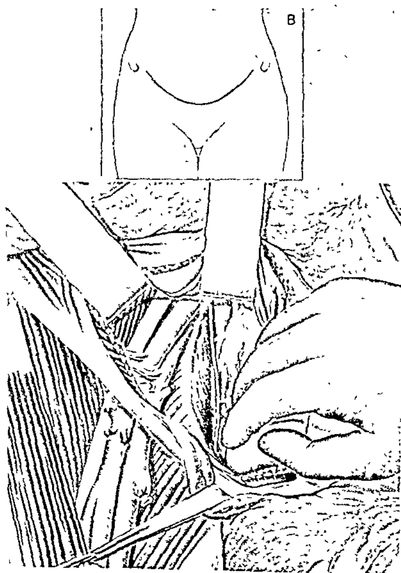


FIGURE 728 Radical groin dissection (*continued*). Completion of the deep iliac portion of the dissection. The inguinal ligament is not divided, but excellent exposure is obtained by dividing the external and internal oblique muscles as well as the lower portion of the rectus abdominis muscle. Inset *B* shows the skin incision used for a bilateral groin dissection, and the shaded area indicates the extent of the dissection. (S. L Gumport a[illegible]

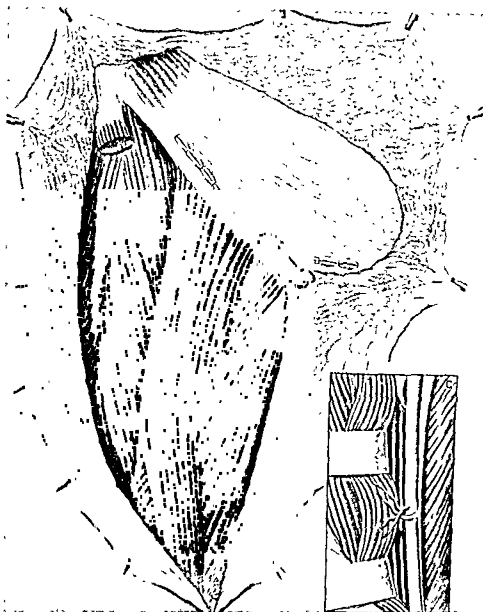


FIGURE 729. Radical groin dissection (*concluded*). The aponeurosis of the external oblique muscle and the rectus abdominis muscle are reapproximated, and the sartorius muscle is used to cover the femoral vessels and nerve. Inset *C* shows preservation of the blood supply to the sartorius muscle. (S. L. Gumport and H. W. Meyer: Surgery, Vol. 38.)

can be further closed by suturing the shelving portion of the inguinal ligament to the pectineus fascia.

The aponeurosis of the external oblique is next closed. The sartorius is then divided close to the anterior superior spine and rotated medially to cover the femoral vessels and nerves. This is sutured to the inguinal ligament above and to the underlying muscles below, as indicated in Figure 729. The entire area is then drained with Penrose drains either through the angles of the incision or through separate stab wounds. The use of suction drainage under the flaps by placing urethral catheters with multiple holes through the upper and lower portions of the wound to be attached to suction avoids accumulation of lymphatic fluid and in addition tends to hold the flaps in place. If the skin edges cannot be closed without undue tension, a split skin graft is indicated. Patients are kept in bed for approximately ten days, and elastic bandages should be applied to the extremities to avoid lymphedema.

Necrosis of the skin edges and separation of the suture line are the most common complications. These can be minimized by avoiding undue undermining of the skin flaps and by leaving the skin sutures in place for longer than usual.

OPERATIONS UPON THE URETHRA

MEATOTOMY

The meatus is the least elastic portion of the male urethra. Meatotomy is indicated when the meatus is too small for necessary instrumentation.

Technique of Operation

By using a very fine hypodermic needle, a small quantity of procaine is injected into the ventral wall of the urethra near the point of constriction. The constriction is then divided in the ventral midline until a 28 French sound may be passed. A fine chromic catgut suture is placed to unite the mucosa and skin at the upper end of the incision. The lateral margins of the mucosa and skin are also sutured. The sutures prevent closure of the meatus while the wound is healing.

INTERNAL URETHROTOMY

General Considerations

When strictures of the urethra cannot be treated by dilatation, or when quick results are desirable, internal urethrotomy is indicated. This operation is not to be attempted when an instrument cannot be passed through the stricture.

Dangers and Safeguards

Hemorrhage is the most serious complication of internal urethrotomy. Hemorrhage is more likely to occur after section of a stricture in the membranous urethra. Young advises that this type of operation be reserved for strictures of the pendulous and anterior portions of the bulbous urethra. External urethrotomy is the operation of choice for strictures of the membranous portion of the urethra that cannot be successfully treated by dilatation.

If serious hemorrhage occurs after urethrotomy, a large catheter in the urethra may be sufficient to control bleeding. A tight adhesive dressing about the penis with a catheter in the urethra should be tried if bleeding is profuse. In severe cases of hemorrhage external urethrotomy may be advisable to expose and control the bleeding vessels.

Technique of Operation (Fig. 730)

The Maisonneuve urethrotome may be used. The bladder should be filled with water or urine before the operation is begun to afford adequate room within the bladder for the use of instruments.

A filiform is first passed into the bladder, into the end of which the staff of the

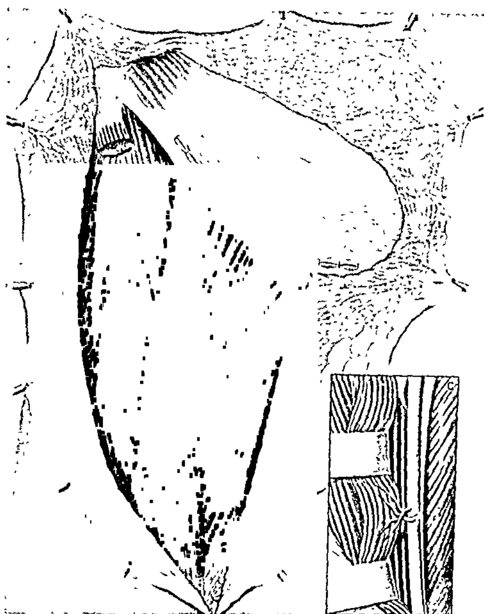


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Necrosis of the skin edges and separation of the suture line are the most common complications. These can be minimized by avoiding undue undermining of the skin flaps and by leaving the skin sutures in place for longer than usual.

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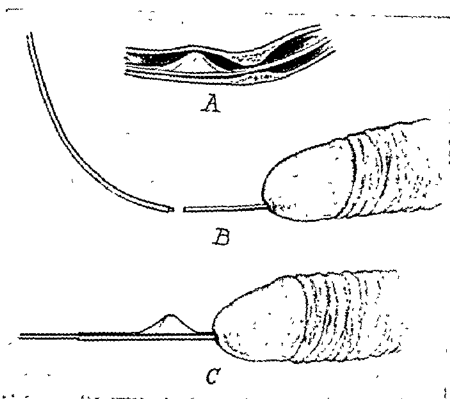


FIGURE 730. Internal urethrotomy using the Maisonneuve urethrotome. *A*, Longitudinal section of urethra showing filiform through stricture as guide for urethrotome. *B*, Filiform passed through stricture. Guide to be screwed on to filiform *C*, Knife is introduced along grooved guide. (Redrawn from Young's Practice of Urology.)

urethrotome is firmly screwed. The urethrotome is then passed as far as the prostatic portion of the urethra. Into the grooved staff an obturator carrying a guarded knife *is inserted and passed down to the stricture. As the penis is held taut, the blade of the* instrument is pushed through the stricture. A decrease in resistance indicates that the knife has passed through the stricture. More than one stricture may be present and require division. The cut should always be made in the roof of the urethra. The size of the knife determines the depth of the cut through the stricture.

After the stricture has been cut the urethrotome is withdrawn and detached from the filiform. A filiform follower is attached to the filiform and passed through the stricture. Sounds up to 28 to 30 French are then passed to dilate the stricture.

After the operation the bladder should be irrigated daily. To prevent re-formation of the stricture, sounds are passed every four or five days for a few weeks and thereafter every week for several months.

EXTERNAL URETHROTOMY

General Considerations

External urethrotomy is indicated for impassable strictures, and to divert the urinary stream by draining the bladder for a plastic operation upon the urethra. This operation is also indicated for old strictures which have been unsuccessfully treated by other methods and when complicated by abscesses or sinuses. Strictures of the bulbomembranous urethra should be treated by the external operation.

Technique of Operation with a Guide (Fig. 731)

The patient is placed in a slightly exaggerated lithotomy position. A filiform bougie is passed through the stricture to be followed by a grooved sound up to the point of stricture. An incision is made through the midline of the perineum directly over the stricture 4 to 6 cm. long. The urethra is opened over the tip of the sound and along the filiform. The scar tissue of the stricture is cut away about the urethra. A strip of urethral mucosa must be left intact along the roof of the stricture. A large sound (up to 30 French) is then passed to dilate the entire urethra.

To maintain the caliber of the urethra, a soft rubber catheter is passed through

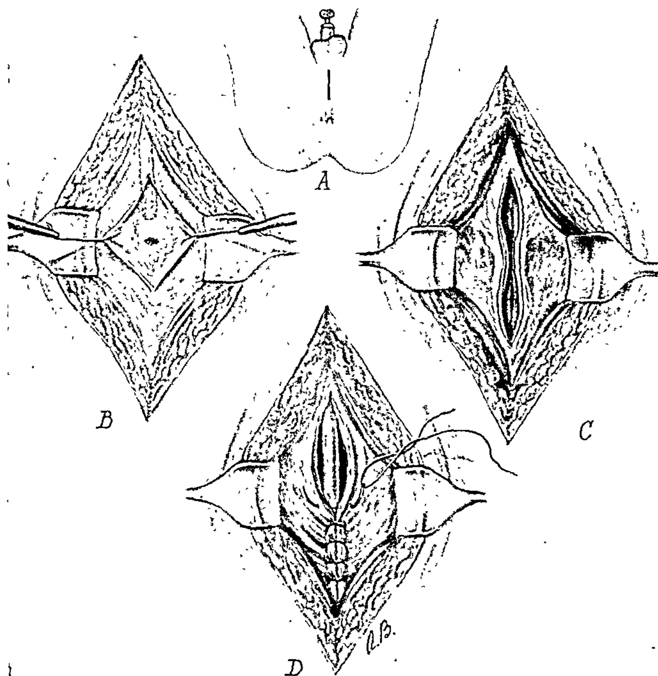


FIGURE 731. Technique of external urethrotomy *A*, Location of skin incision Sound passed into urethra to site of stricture *B*, Incision completed down to stricture Sound in anterior urethra as a guide. *C*, Fibrous tissue has been resected about stricture. *D*, Defect in urethra closed over rubber catheter (Modified from Young's Practice of Urology.)

the penis into the bladder. Over the catheter the perineal tissues are sutured with fine chromic catgut.

Mucosa will form in the new channel about the retention catheter. Some leakage may occur through the wound, but this does not usually prevent complete healing.

Technique of Operation without a Guide

When a filiform cannot be passed through the stricture, the operation is usually *more difficult. Extensive and useless dissections* may be made in an effort to identify the urethra. The injection of methylene blue under some pressure may force the solution through a tortuous or narrow stricture and aid in its identification.

A grooved sound is passed down to the point of stricture, and an incision is made through the midline of the perineum over the tip of the instrument. This identifies the urethra, and the stricture can usually be found and excised.

When the stricture cannot be definitely *identified through the perineum,* the bladder may be opened through a small incision and a sound passed downward to the point of stricture. The urethra is then opened above the stricture with the sound as a guide.

If the stricture cannot be split open, it should be completely resected. When this is necessary, the perineal tissues are sutured over a retention catheter to maintain the new urethral lumen. The cystotomy wound is closed without drainage.

The after-treatment of a patient undergoing urethrotomy is important. The retention catheter should be left in place until the perineal wound is healed. The anterior urethra should be kept clean by irrigation. After ten to fourteen days the catheter is removed and, after the third week, the stricture is kept open by dilatation with sounds.

OPERATION FOR RUPTURE OF URETHRA

General Considerations

The most common site of rupture is in the bulbous urethra. Rupture of the posterior urethra is not infrequently associated with fracture of the pelvis.

Bleeding into the tissues and extensive extravasation of urine may follow rupture of the urethra. Operation is indicated for hematoma formation and extravasation of urine. Minor tears in the urethra unassociated with extensive bleeding and extravasation may be successfully treated with an indwelling catheter.

Technique of Operation

When extravasation of urine exists, an immediate cystostomy should be done to prevent further leakage.

To expose the urethra, a midline incision is made in the perineum. Blood clots and urine are evacuated. The urethra is located and closed with sutures over an indwelling catheter. *If difficulty is experienced in* locating the torn ends of the urethra, retrograde catheterization through the bladder may be necessary. When accurate anastomosis is impossible, good results may be obtained by uniting a portion of the urethral wall over a catheter.

When a rupture of the posterior urethra is associated with fracture of the pelvis,

repair is more difficult. The posterior urethra is exposed through an inverted V-shaped incision in the perineum which extends through the central tendon and rectourethral muscle.

Clots and urine are evacuated, and the torn ends of the urethra are united over a catheter. If the tear is near the prostate, this organ may be grasped and drawn downward while the urethra is being sutured.

Strictures may form after rupture of the urethra. This should be guarded against by dilatation for several months. If there is much injury to the tissues in and about the prostate, complete loss of sexual powers may result. When there has been extensive extravasation of urine in neglected cases, multiple incisions may be necessary for drainage of the lower abdominal wall, scrotum and perineum.

HYPOSPADIAS

General Considerations

Three types of hypospadias are described: the glandular, the penile (penoscrotal) and the perineal (perineoscrotal.) The anomaly is associated frequently with other malformations of the external genitals. In most instances there is some degree of chordee giving downward contraction and bowing of the penis. There also occurs a hooding of the foreskin with a redundancy of preputial skin on the dorsal and lateral aspects and an insufficiency of skin on the ventral aspect of the penis.

Many different operations have been described for the various types of hypospadias, most of the procedures requiring two or more stages.

The glandular type of hypospadias, in which the urethral opening is situated but a few millimeters below the normal meatus, produces no functional disturbance and requires no treatment. The functions of micturition and insemination can be carried out in a normal and satisfactory fashion.

Infants with hypospadias should not be circumcised, since the prepuce may be utilized for future plastic repair.

Of the numerous techniques available, three will be described briefly. In all instances when there is an associated chordee, this is corrected as a preliminary procedure.

Technique of Cecil

An external perineal urethrotomy is done to divert the urinary stream. An incision is made about the defect and glans and shaft of the penis outlining flaps about 2 cm. wide. The margins of the flaps are dissected up, leaving them thick enough to avoid damage to their blood supply. These flaps of ventral penile skin are then sutured with interrupted sutures over a catheter to form the new urethral tube. A vertical incision is then made in the scrotum and the penis brought down to the resulting defect by suturing the margins of the penile skin which remain after the flap is closed to the margins of the scrotal incision.

The penis is freed from the scrotum in approximately two months, at which time flaps of scrotal skin are utilized to form the new ventral surface of the penis. Excellent results can be obtained by using this method of repair, with small chance of fistula formation.

Technique of Denis Browne

A perineal urethrotomy to divert the urine is first done. Parallel incisions are made along the ventral surface of the shaft of the penis and joined by a curved incision extending around the external urinary meatus. This strip of skin is not raised or otherwise disturbed. However, lateral skin flaps are raised from the lateral surfaces of the penis. These lateral flaps are raised widely on each side so that they can fall together loosely with considerable skin to spare, and there must not be any tension on the joining flaps. In order to obtain this, a longitudinal dorsal slit is made. The lateral flaps are then approximated in the midline ventrally with deep tension sutures and the flap edges carefully approximated with fine catgut. A small incision is made in the scrotum on each side at the base of the penis to permit drainage of accumulated serum. The denuded area over the dorsal area of the penis which results from the longitudinal relaxing incision is allowed to epithelialize spontaneously.

Technique of MacCollum and Gross

Chordee, if present, is corrected when the child is approximately two or three years of age. However, reconstruction of the urethra is deferred until late childhood or the puberal years.

A Foley catheter is passed into the bladder through the existing urethral meatus to ensure a dry operative field. An inverted V-shaped incision is made just distal to the urethral opening, and a specially constructed trocar is passed through the shaft of the penis to emerge at the tip of the glans. A split-thickness Thiersch skin graft of suitable size is then taken from a nonhair-bearing part of the body. The graft is wrapped around a urethral catheter and tied in place at each end to prevent slipping, the epidermal side of the graft being placed inward. The catheter and graft are then passed through the previously placed trocar and the trocar removed. Approximately six months are now allowed to ensure adequate healing of the newly constructed urethra. During this time a catheter is left in place at all times and should be changed approximately once a day.

In approximately six months the newly constructed penile urethral tube is anastomosed to the pre-existing urethral meatus. A perineal urethrotomy is established to divert the urinary stream. The skin is then incised around the two openings and the cutaneous flaps closed with a running catgut suture. These are reinforced with interrupted silk sutures. Subcutaneous sutures are placed and the skin flaps approximated over the closed urethral opening with mattress sutures of silk. The catheter which has been left in place through the perineal urethrotomy is removed in approximately ten days, after which the urethrotomy will close spontaneously and voiding will occur through the newly constructed urethra.

EPISPADIAS

General Considerations

Epispadias is found in both male and female. It is often associated with exstrophy of the bladder. Three types are recognized in the male: the glandular or balanic, the

penile and the complete. Epispadias is rare compared to hypospadias. The ratio of the former to the latter is about 1 to 150.

Mild epispadias can be corrected easily by the freeing up and approximation of tissue dorsal to the urethra. The more severe types, in which there is an associated defect of the sphincter muscles of the bladder with resultant urinary incontinence, are difficult to repair. However, results of repair are such that ureteral transplantation should not be done unless plastic repair has failed.

Dangers and Safeguards

The best time for operation is probably at three to six years of age so that recon-

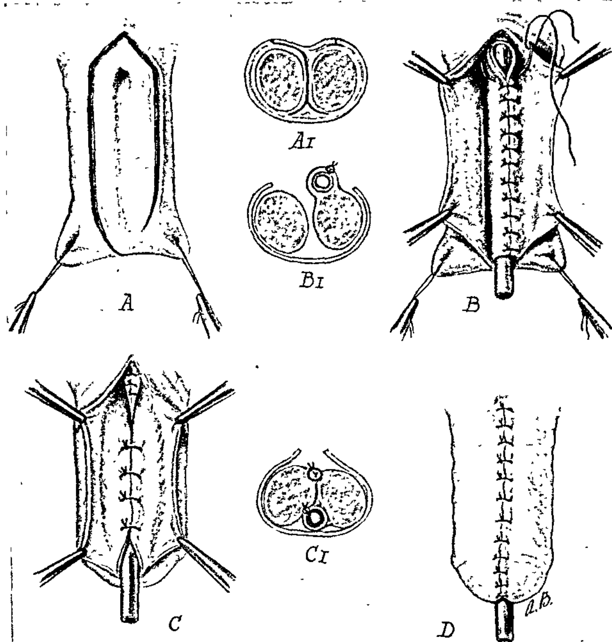


FIGURE 732. Young's operation for epispadias A, Penis held in position by traction sutures Lines of incision for formation of urethra A_1, Cross section of penis showing extent of incisions B, New urethra formed by suturing skin flaps over rubber tube with catgut B_1, Cross section showing extent of dissection and new urethra formed over rubber tube C, Corpora sutured together with chromic catgut C_1, This shows rotation of one corpus, placing urethra ventral to the corpora. D, Skin and glans closed with interrupted sutures of silk. (Redrawn from Young's Practice of Urology.)

struction will be completed before school age and tissues will be of sufficient size to permit ease of operation. If incontinence is present, earlier operation is advisable.

The technique of the operation is difficult, and the results are frequently unsatisfactory. Failure or partial failure is not infrequent. Infection and sloughing of tissues are often the causes of failure. Stricture of the urethra may be a late complication.

Technique of Young's Operation for Penile Epispadias (Fig. 732)

An incision is made around the urethral opening and along each side of the groove in the penis. Flaps of skin are raised on each side. On one side the dissection is carried down between the corpora. On the other side a narrow flap is shaped so that the blood supply may be preserved. A new urethra is then formed by suturing the skin margins over a rubber catheter. To place the urethra on the ventral side of the penis, the corpora are sutured together. The skin and glans are closed to complete the operation.

OPERATIONS UPON THE TESTICLE AND SPERMATIC CORD

CASTRATION (ORCHIECTOMY)

Indications

Castration is indicated for malignant tumors, selected cases of torsion, advanced tuberculosis, certain severe injuries, undescended testis when too high in the abdomen to place in the scrotum, and as an elective procedure in certain large hernias to permit more secure plastic repair. Orchiectomy is done frequently as a part of the management of carcinoma of the prostate.

Dangers and Safeguards

To avoid legal complications, *written permission* should be obtained from the patient, parent or guardian before a testicle is removed.

Hematomas will form in the loose tissue of the scrotum after removal of a testicle unless great care is exercised in controlling all bleeding vessels. A hematoma may necessitate a secondary operation to evacuate a clot, which predisposes to infection, extensive induration of tissues and delayed healing.

Infection may result from inadequate preparation of the skin, delayed operation following severe trauma, and existing sinus tracts in cases of tuberculosis. In tuberculous cases the severed end of the vas may infect the scrotal tissues. *Tetanus* may develop after trauma.

Adequate support of the scrotum will minimize postoperative edema.

Technique of Operation

An incision is made in the upper anterior wall of the scrotum about 5 cm. long. This incision is extended through the dartos and cremasteric fibromuscular layers to expose the spermatic cord and testicle. The testicle is then delivered through the wound for examination.

In cases of torsion the testicle should be preserved if correction is possible and the blood supply adequate. When sinus tracts exist, they should be excised when possible.

Minor wounds of the testicle may be sutured, or a portion of the testicle may be resected.

After delivery of the testicle the surrounding tissues are dissected from the tunica and cord up to the external abdominal ring. The vessels of the cord are ligated with a strong ligature and divided. The vas is ligated and divided separately, and, if tuberculous, is exteriorized to prevent infection of the scrotal tissues. After careful ligation of all bleeding vessels the scrotal layers are closed with fine catgut and the skin with silk.

Intracapsular Orchiectomy

When orchiectomy is being done for its effect on endocrine-dependent tumors such as carcinoma of the prostate, an improved cosmetic result may be obtained by utilizing the intracapsular technique. By removing only the endocrine tissue of the testicle, and leaving the epididymis, fascia and tunica vaginalis, the scrotum does not contract up against the perineum, but rather retains somewhat normal contours.

The testicles are exposed by incising through the scrotal skin, fascia and tunica vaginalis. The tunica albuginea is then incised over the convex anterior surface and the testicular tissue expelled by pressure and wiped away with gauze from its attachment at the rete testis. Bleeding is controlled by ligature and the cut edges of the tunica approximated with running catgut. The skin edges of the scrotum are then closed with interrupted sutures. Drainage is not required.

UNDESCENDED TESTICLE

General Considerations

Operation for undescended testicle is indicated before the age of puberty, preferably between the ages of nine and twelve. Since a testicle retained within the inguinal canal or abdomen is sterile, it is of great importance that it be placed in the scrotum at or before puberty. Early operation is contraindicated, since it is well known that an undescended testicle in early life may descend into the scrotum before the age of puberty. Some authors believe that the administration of growth-stimulating hormones may influence the descent of the testicle before puberty.

Undescended testicles that cannot be placed in the scrotum may be removed if the patient or patient's parent or guardian is willing. It is generally believed that the undescended testicle becomes malignant more frequently than the testicle in the scrotum. Other reasons for operation upon an undescended testicle are trauma and the psychological effect upon a patient who is unlike his fellow creatures. A testicle within the inguinal canal or near the external inguinal ring is more exposed to trauma than one in the scrotum.

Dangers and Safeguards

The most important danger of operation upon an undescended testicle is *damage to its blood supply.* The processus vaginalis is closely adherent to the vessels of the spermatic cord, and the latter are easily cut or torn during dissection. Too much tension upon the anchored testicle may also disturb its blood supply. Either error

may result in gangrene or atrophy of the testicle. Careful and complete dissection of the cord structures to ensure adequate mobilization is essential.

An improperly prepared operative field may result in infection and cause operative failure.

If the condition is bilateral, one side is operated upon at a time. If both sides are repaired at the same time by the Torek method, there is danger that motion of the thighs will tear out stitches.

Technique of the Torek Operation (Fig. 733)

An incision is made as for operation upon an inguinal hernia. The aponeurosis of the external oblique is divided as in hernia repair. An indirect hernia usually is present. An open or closed processus vaginalis is always present, to which the spermatic cord is attached.

The processus vaginalis is carefully separated from the cord up to the transversalis fascia of the internal ring, or higher if necessary. After separating all tissue from the cord, leaving only the vessels and vas deferens, the gubernaculum is divided, freeing the testicle. If a hernial sac exists, it should be ligated and removed.

By using blunt dissection, usually with one or two fingers, a pocket is made in the scrotum to receive the testicle. This pocket is temporarily packed with gauze to approximate its normal form.

The location of the incision in the skin of the thigh depends upon the length of the spermatic cord. This is easily measured by bringing the testicle down beside the scrotum to mark the point where it may be attached without too much tension. At the point selected a transverse or slightly oblique incision is made in the skin of the thigh. The deep fascia is exposed. The saphenous vein may be near and must be avoided. An incision of corresponding length is made in the scrotum over the gauze pack at a point where it will accurately fit the thigh incision when sutured. The posterior margin of the scrotal incision is now sutured to the upper margin of the thigh incision. To promote approximation of skin surfaces, interrupted sutures of fine chromic gut are used inside to evert the skin margin. The pack is removed from the scrotum, and the testicle is drawn down through the scrotum with a clamp attached to the gubernaculum. The gubernaculum is sutured to the deep fascia of the thigh with two or three stitches of fine chromic catgut or silk. Stitches may be passed through the tunica of the testicle if necessary to fix it to the fascia. The anterior skin margin is closed with interrupted sutures of fine silk.

A small wick of petrolatum or plain gauze is passed beneath the scrotum to serve as a dressing for the posterior portion of the incision. A small dressing will cover the anterior suture line.

At the end of two or three months the scrotum and testicle may be separated from the thigh and the testicle placed in the scrotum. Local anesthesia is usually sufficient for this minor operation.

If sufficient mobilization of the chord structures can be obtained, and this is possible in most instances, implantation of the gubernaculum into the thigh may be unnecessary, and the procedure described by Bevan can be used. A traction suture of silk is passed through the tunica vaginalis and lower 2 or 3 mm. of the testicle itself and the suture passed through the lowermost point of the scrotum. The testicle is then pulled down into the scrotum, care being taken that the cord is not twisted. Traction

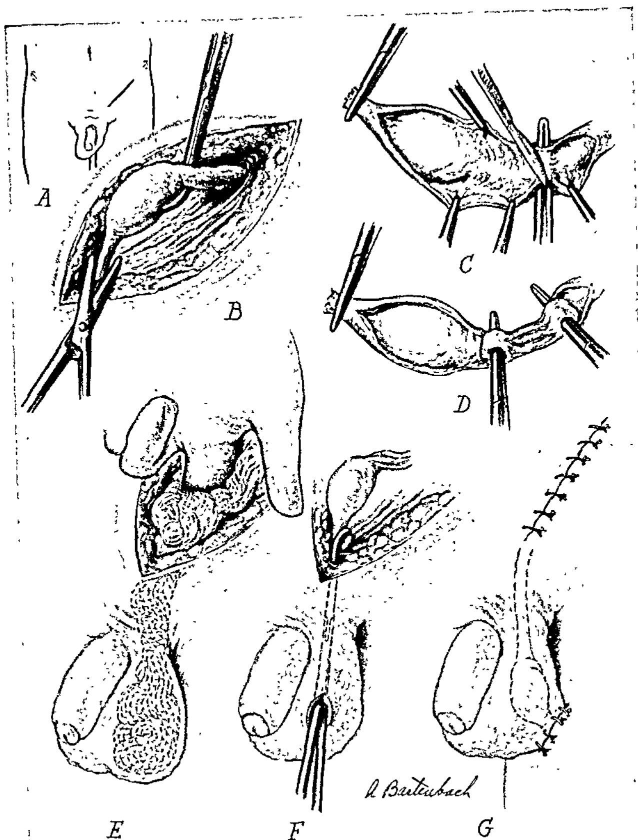


FIGURE 733. Torek type of operation for undescended testicle. *A*, Inguinal hernia incision. *B*, Testicle and gubernaculum dissected free. *C*, Dividing processus vaginalis over cord, using groove director as a guide *D*, Stripping processus vaginalis from cord with hemostats. *E*, The scrotum is prepared for testicle by finger dissection and packing with gauze. *F*, Incision made over gauze pack and testicle drawn through scrotum with clamp. *G*, Gubernaculum sutured to fascia of thigh. Incision in skin of thigh sutured to skin of scrotum (Redrawn from McKenna and Ewert: J.A M.A.)

may result in gangrene or atrophy of the testicle. Careful and complete dissection of the cord structures to ensure adequate mobilization is essential.

An improperly prepared operative field may result in infection and cause operative failure.

If the condition is bilateral, one side is operated upon at a time. If both sides are repaired at the same time by the Torek method, there is danger that motion of the thighs will tear out stitches.

Technique of the Torek Operation (Fig. 733)

An incision is made as for operation upon an inguinal hernia. The aponeurosis of the external oblique is divided as in hernia repair. An indirect hernia usually is present. An open or closed processus vaginalis is always present, to which the spermatic cord is attached.

The processus vaginalis is carefully separated from the cord up to the transversalis fascia of the internal ring, or higher if necessary. After separating all tissue from the cord, leaving only the vessels and vas deferens, the gubernaculum is divided, freeing the testicle. If a hernial sac exists, it should be ligated and removed.

By using blunt dissection, usually with one or two fingers, a pocket is made in the scrotum to receive the testicle. This pocket is temporarily packed with gauze to approximate its normal form.

The location of the incision in the skin of the thigh depends upon the length of the spermatic cord. This is easily measured by bringing the testicle down beside the *scrotum to mark the point where it may be attached without too much tension.* At the point selected a transverse or slightly oblique incision is made in the skin of the thigh. The deep fascia is exposed. The saphenous vein may be near and must be avoided. An incision of corresponding length is made in the scrotum over the gauze pack at a point where it will accurately fit the thigh incision when sutured. The posterior margin of the scrotal incision is now sutured to the upper margin of the thigh incision. To promote approximation of skin surfaces, interrupted sutures of fine chromic gut are used inside to evert the skin margin. The pack is removed from the scrotum, and the testicle is drawn down through the scrotum with a clamp attached to the gubernaculum. The gubernaculum is sutured to the deep fascia of the thigh with two or three stitches of fine chromic catgut or silk. Stitches may be passed through the tunica of the testicle if necessary to fix it to the fascia. The anterior skin margin is closed with interrupted sutures of fine silk.

A small wick of petrolatum or plain gauze is passed beneath the scrotum to serve as a dressing for the posterior portion of the incision. A small dressing will cover the anterior suture line.

At the end of two or three months the scrotum and testicle may be separated from the thigh and the testicle placed in the scrotum. Local anesthesia is usually sufficient for this minor operation.

If sufficient mobilization of the chord structures can be obtained, and this is possible in most instances, implantation of the gubernaculum into the thigh may be unnecessary, and the procedure described by Bevan can be used. A traction suture of silk is passed through the tunica vaginalis and lower 2 or 3 mm. of the testicle itself and the suture passed through the lowermost point of the scrotum. The testicle is then pulled down into the scrotum, care being taken that the cord is not twisted. Traction

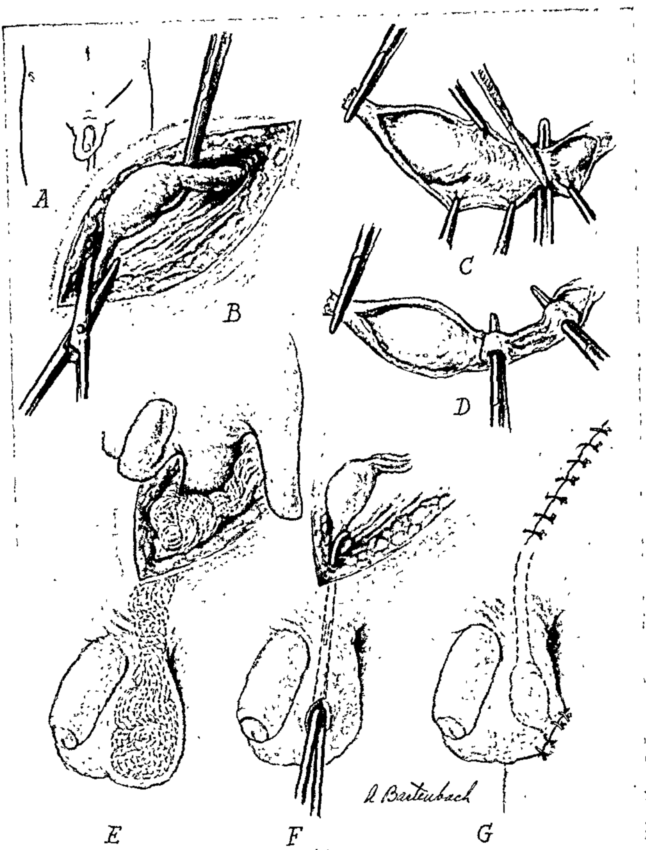


FIGURE 733 Torek type of operation for undescended testicle *A*, Inguinal hernia incision. *B*, Testicle and gubernaculum dissected free. *C*, Dividing processus vaginalis over cord, using groove director as a guide *D*, Stripping processus vaginalis from cord with hemostats *E*, The scrotum is prepared for testicle by finger dissection and packing with gauze. *F*, Incision made over gauze pack and testicle drawn through scrotum with clamp *G*, Gubernaculum sutured to fascia of thigh. Incision in skin of thigh sutured to skin of scrotum (Redrawn from McKenna and Ewert: J A.M A)

is then applied to the testicle by attaching this suture to a rubber band which in turn is fixed to adhesive attached to the opposite thigh. This traction suture prevents retraction of the testicle and can be removed after approximately one week.

EPIDIDYMECTOMY

Indications

Epididymectomy is indicated for tuberculous epididymitis. It may also be the treatment of choice in selected cases of chronic nonspecific epididymitis.

Tuberculosis of the epididymis is usually only a part of a general urogenital tuberculosis. By early removal of a tuberculous epididymis, involvement of the testicle is prevented and further dissemination of the disease may be avoided. However, in early cases treatment with the antituberculosis drugs may result in clinical arrest and should be used first in all types of genitourinary tuberculosis.

Technique of Operation (Fig. 734)

The incision may be made in the scrotum either vertically or transversely, or an inguinal incision may be used. The testicle and epididymis are delivered through the wound. All tissues are separated from the cord and epididymis. Dissection may be difficult if sinuses are present.

The vas deferens is isolated from the cord and divided below the external abdominal ring between clamps. If the upper end of the vas is permitted to retract into the tissues, an abscess may later develop. The cut ends of the vas are cauterized with phenol followed by alcohol. Through a stab wound in the skin of the upper

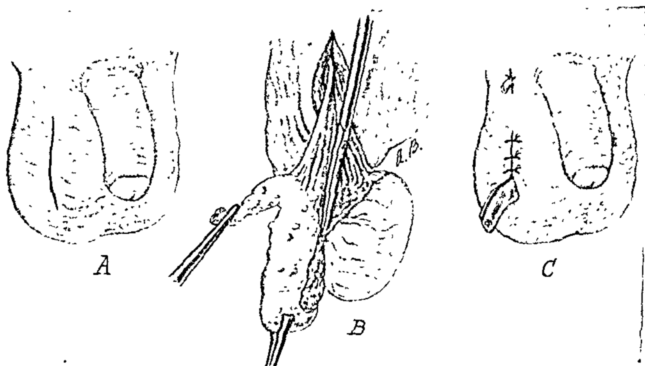


FIGURE 734. Technique of epididymectomy. *A*, Line of incision in scrotum. *B*, Lower end of vas and epididymis dissected from the cord and testicle. The blood supply to the testicle is carefully preserved. *C*, Wound in scrotum closed. The wound is drained. Severed end of vas sutured in stab wound to prevent infection. (Modified from Lowsley and Kirwin. Clinical Urology.)

portion of the scrotum, the upper end of the vas is withdrawn and fixed to the skin with a suture. The lower portion of the vas is dissected from the cord down to the epididymis. With careful sharp dissection the epididymis is separated from the testicle, beginning at the globus minor. As the epididymis is separated from the testis, the blood supply to the latter is carefully preserved.

After the ligation of all bleeding vessels the testicle is replaced in the scrotum, the wound is closed in layers, and a rubber tissue drain is inserted through the lower end of the incision in the scrotum.

EXCISION OF HYDROCELE

A hydrocele may be treated by aspiration and injection of a sclerosing solution, or by excision. Excision is the treatment of choice in the majority of patients.

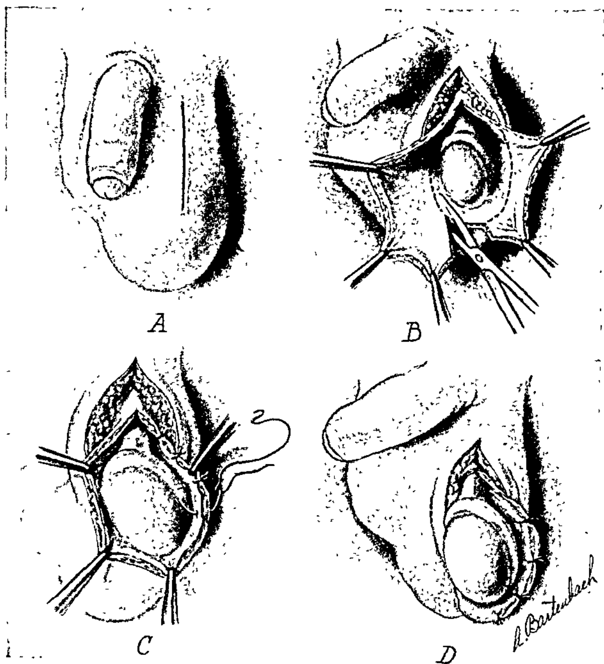


FIGURE 735. Excision of hydrocele. *A*, Line of incision in upper scrotum. *B*, Hydrocele sac is excised along dotted. line. *C*, Sutures placed to control bleeding. *D*, Margins of hydrocele sac sutured behind testis.

Technique of Operation (Fig. 735)

An incision about 7 to 8 cm. long is made over the upper portion of the hydrocele, beginning just below the external abdominal ring. This incision is extended inward to the distended tunica vaginalis. The fascia is separated from the wall of the tunica, and the hydrocele sac is opened and emptied. The sac is then excised to within about 1 to 2 cm. of the reflection of the tunica on the testis. All bleeding vessels must be carefully controlled by suture or ligature to prevent the development of a postoperative hematoma. A running suture of catgut along the line of excision may be used for hemostasis. The cut edges of the tunica are sutured behind the testicle and epididymis. If hemostasis is complete, drainage is not necessary. The tendency for hematoma to develop is great, however, and a small rubber tissue drain brought out through a stab wound in the scrotal tip may be used. A scrotal support should be worn while the patient is in the hospital and for several weeks thereafter.

EXCISION OF SPERMATOCELE

Surgical removal is the treatment of choice for large spermatoceles. Small spermatoceles without symptoms do not require any treatment.

Technique of Operation

The technique used in the removal of a spermatocele is similar to that used for the excision of a hydrocele.

Through an incision in the anterior wall of the scrotum the testicle with the spermatocele is delivered. The cyst is usually opened and freed from surrounding tissue. The open cyst is cut away, leaving a small portion to prevent injury to the epididymis. The portion of cyst wall remaining may be sutured around the cord.

After carefully suturing or ligating all bleeding vessels, the wound in the scrotum is closed without drainage.

VASECTOMY

Indications

Bilateral vasectomy is frequently done preliminary to prostatectomy to avoid postoperative epididymitis. This operation is also indicated when sterilization of the male is advisable.

Technique of Operation

Local anesthesia is usually used. An incision about 3 cm. long is made through the wall of the upper scrotum to expose the spermatic cord. The vas is easily located by palpation. It may be fixed with an Allis clamp until it is dissected free from its surrounding fascia. A section of the vas about 2 cm. long is excised, and the cut ends are securely ligated with chromic catgut or silk. The wound is closed in layers without drainage. A gauze dressing held in place by a scrotal suspensory is satisfactory.

ANASTOMOSIS OF VAS DEFERENS

The vas may be severed by accident during a hernia repair or operation upon the scrotum. It may be repaired with the expectation of future function. Repair may also be desired for restitution of a previously ligated and sectioned vas.

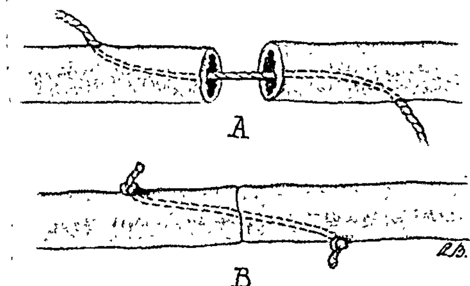


FIGURE 736 Simple method of vas deferens anastomosis with strand of plain catgut.

Technique of Operation (Fig. 736)

The ends of the severed vas are cut squarely across to afford accurate approximation. A strand of plain no. 0 catgut is passed through the lumen of each severed end and out through the wall of each segment about 1 cm. from the point of section. Knots are tied in each end of the catgut against the outer walls of the vas so that there will be just enough tension on the gut to approximate the ends of the vas. No other sutures are necessary.

O'Conor has collected a series of 299 cases of anastomosis of the vas by using silkworm gut, dermal, horsehair, tantalum wire, stainless steel wire or silver wire as a removable splint. The suture material is passed into the lumen of the vas about 2 cm. above its severed end, then through the lumen of each end and out through the wall of the vas 2 cm. below the site of the anastomosis. The severed ends of the vas are approximated, and the ends of the splinting suture material are passed through the skin and fixed with a split shot. O'Conor reports that Michelson uses two stainless steel wires as a splint and unites the ends of the vas with three sutures of fine stainless steel wire. Successful suture of the vas deferens may be expected in 35 to 40 per cent of such operations.

OPERATION FOR VARICOCELE

General Considerations

The mere presence of a varicocele is not an indication for operation. Operation may be advisable in carefully selected cases when there is great nervousness and fear of the loss of sexual power. Pain in the testicle or along the cord and in the inguinal region may be a justifiable reason for operation. In many cases a tactful explanation of the condition to the patient and the fitting of a suspensory will make operation unnecessary. When operation is done, alleviation of symptoms cannot be anticipated

in all cases. In the older operation the cord was approached through an incision in the scrotum, and a long segment of the dilated tortuous varicosities was removed. This procedure has in general been abandoned because of poor results and the frequency of hematoma formation, testicular atrophy and subsequent hydrocele development. Since varicocele is accompanied in many instances by a small inguinal hernia, the preferred approach is through an inguinal incision, described below.

Technique of Operation (Fig. 737)

The classic oblique herniorrhaphy incision is made, and the fibers of the external oblique are divided and the entire spermatic cord mobilized as for the classic herniorrhaphy. The cremasteric fibers are opened near the internal ring. At this point the internal spermatic vein usually consists of one or possibly two trunks; these are separated carefully from the vas deferens and internal spermatic artery and a short segment removed between ligatures. The internal ring is then examined for possible hernia sac and the hernia sac mobilized, ligated and excised as indicated. The

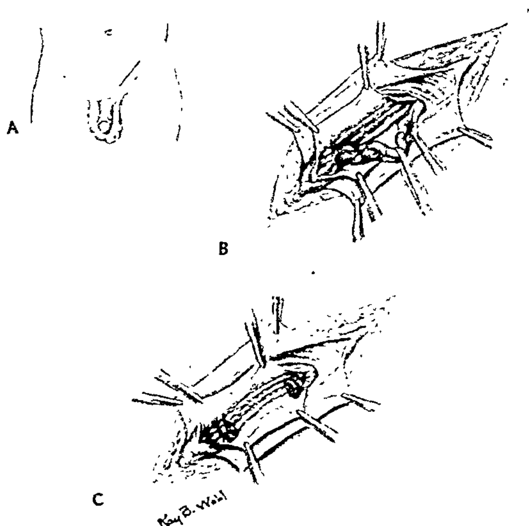


FIGURE 737 Operation for varicocele *A*, Incision similar to that used for inguinal herniorrhaphy. *B*, The external oblique aponeurosis has been divided and the cremasteric fascia opened to expose the structures of the spermatic cord *C*, A short segment of the internal spermatic vein is removed between ligatures.

cremasteric fibers are then reapproximated and any additional herniorrhaphy repair completed. The patient is advised to wear a suspensory after operation.

PATENT URACHUS

Occasionally the urachus will remain patent and require surgical treatment. It may remain completely patent with a urinary fistula at the umbilicus, either end may fail to close, or both ends may close, forming a urachal cyst. Carcinoma, tuberculosis and calculi are rare complications.

Complete surgical removal of the patent urachus with a section of the bladder wall is necessary to produce a cure. This operation can be done through a paramedian incision. If an infected cyst of the urachus exists, it should be drained and removed at a later operation.

OPERATIONS UPON THE BLADDER AND PROSTATE

WOUNDS OF THE BLADDER

General Considerations

A wound of the bladder is an *urgent* emergency. When treatment is delayed, the mortality rate is high. If a penetrating wound involves the bladder, or rupture of the bladder is suspected, suprapubic exploration of the bladder is always indicated.

In civil practice, rupture of the bladder is commonly due to crushing injuries of the pelvis. A distended bladder is more susceptible to rupture than an empty bladder. Wounds of the bladder may result from careless or injudicious intravesical instrumentation. War wounds of the bladder are always associated with wounds of other structures and should always be suspected when treating wounds in the pelvic region.

Rupture of the bladder may be intraperitoneal or extraperitoneal, or a combination of the two types. The need for early operation is imperative in both injuries, although the prognosis is more serious in intraperitoneal rupture.

Technique of Operation

Hemorrhage and shock are often serious complications of bladder injuries, and must be treated before or, if not too serious, during the surgical operation upon the bladder

A suprapubic cystotomy is first made to explore the extent of the injury. Since small puncture wounds are often difficult to find, careful examination is necessary. If the wound in the bladder wall is slight, and there is no extravasation of urine, simple suprapubic cystostomy will suffice. Wounds through the bladder wall should be sutured with catgut. The bladder and tissues infiltrated with urine should be drained.

When intraperitoneal rupture exists, urine and blood should be carefully aspirated. The wound in the bladder is closed with catgut. Suprapubic drainage of the bladder is always indicated. Drainage of the peritoneum and infiltrated tissues is

usually necessary. Injuries of the floor of the bladder with extravasation of urine may require perineal drainage in addition to suprapubic drainage.

SUPRAPUBIC PUNCTURE OF THE BLADDER

Indications

Suprapubic puncture of the bladder with an aspirating needle or trocar is indicated in cases of complete retention of urine as a result of acute infection of the urethra or prostate and for obstruction due to prostatic hypertrophy. In such cases attempts at catheterization may spread infection or produce undesirable trauma.

Suprapubic drainage by puncture is usually used as a temporary measure until the function of the bladder is restored or operative procedure upon the prostate is instituted.

Dangers and Safeguards

Puncture should not be attempted unless the bladder is sufficiently distended to be percussed above the pubes. In passing a needle into the bladder there are two chief dangers: puncture of the prevesical space, which may produce bleeding into the tissues, and wounding of the peritoneum or even the bowel. In patients with large

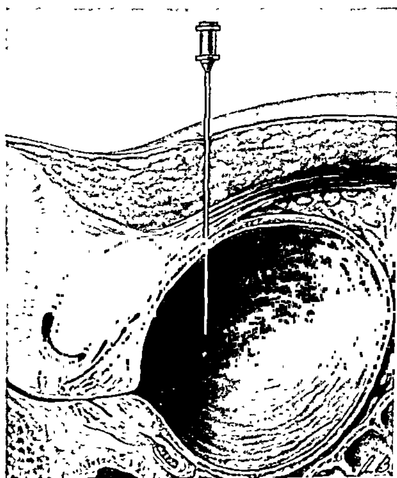


FIGURE 738. Suprapubic puncture of bladder with needle. The needle is introduced vertically 2 cm. above the upper border of the symphysis pubis to avoid entering the prevesical space and peritoneum. (Redrawn from Young's Practice of Urology)

prostates the needle may enter the prostatic tumor if directed too far forward and prevent successful aspiration. Young states that drainage of the bladder with a cannula or catheter has much to condemn it because of the danger of prevesical infection and injury to the bladder and possibly to a loop of intestine.

Technique of Operation (Fig. 738)

A needle of the type used for lumbar puncture may be used to puncture the bladder. After locating the upper limits of the bladder the operator passes the needle gently into the bladder in a vertical position about 2 cm. above the pubes. The depth of the bladder from the surface varies with the thickness of the subcutaneous fat. The distance is usually from 4 to 8 cm. Urine will flow from the needle when it enters the bladder. This flow may be aided by aspiration with a large syringe or suction apparatus.

If a trocar puncture is to be made, a rubber catheter should first be fitted to the caliber of the trocar. A small incision is made in the skin, and through this the trocar is inserted through the skin, muscles and prevesical tissues into the bladder. A preliminary puncture with a needle will add safety to this procedure. When the urine flows freely through the trocar, a catheter is inserted through the trocar, and the latter is withdrawn. The catheter is sutured to the skin or fixed to it with adhesive.

If there is any evidence of bleeding, or a wound of the peritoneum is suspected, immediate cystostomy is indicated. Cystostomy should also be done without delay if any infection of the prevesical space or peritoneum develops later.

SUPRAPUBIC CYSTOSTOMY

Indications

Cystostomy may be indicated for the removal of stones, excision of certain bladder tumors, excision of diverticula, removal of foreign bodies, drainage of the distended bladder due to urethral obstruction, and as a preliminary step in the two-stage suprapubic prostatectomy.

Technique of Operation (Fig. 739)

Local anesthesia is usually satisfactory for simple drainage of the bladder. For operative procedures within the bladder, spinal anesthesia is more suitable.

If the bladder is not distended with urine, it should be filled with saline solution before operation. A retention catheter may be left in the bladder and clamped until all is in readiness for the incision in the bladder wall.

If more than a simple drainage of the bladder is to be done, it is an advantage to place the patient in the Trendelenburg position. This position causes the intestines to gravitate toward the diaphragm and permits better exposure of the bladder.

A transverse suprapubic skin incision or a median incision is made extending upward from the upper border of the symphysis pubis. The length of the incision will depend upon the extent of the proposed operation upon the bladder. The incision is extended through the fascia and between the muscles. By separating the wound with retractors, the fat and areolar tissue covering the distended bladder are exposed.

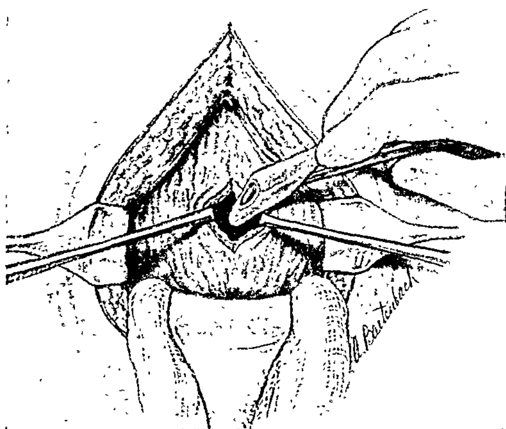


FIGURE 739. Suprapubic cystostomy. The peritoneum is pushed away from the bladder surface *and protected by gauze beneath a retractor. An opening is made in the bladder large enough to admit* a Pezzer catheter (Redrawn from Young's Practice of Urology)

With gauze dissection the fat and peritoneal reflection are carefully pushed upward until the bladder is well exposed. Veins on the surface of the bladder aid in its identification.

The wall of the bladder is fixed by the application of two Allis clamps or by inserting traction sutures to mark the line of incision. At this stage the bladder may be emptied by releasing the indwelling catheter or by trocar and suction. Emptying the bladder before the incision is made prevents wound soiling.

The length of the incision in the bladder wall is determined by the extent of the exploration or operation within the bladder which has been planned For a simple suprapubic drainage, a Pezzer catheter is inserted through a small wound. The bladder wall is sutured snugly about the drainage catheter. A large wound is sutured with the drainage tube emerging at the upper end of the incision to avoid pain and possible bleeding. The intravesical end of the tube should not touch the base of the bladder.

The abdominal wound is closed in layers or with through-and-through sutures. To prevent accidental withdrawal, the cystostomy tube is fixed to the skin with a silk suture or adhesive. A drain is placed in the prevesical space.

A suprapubic bladder wound will usually heal promptly after the bladder is properly emptied through the urethra.

RESECTION OF BLADDER WALL

Indications

A portion of the bladder wall may be resected for chronic ulcers of the bladder, interstitial cystitis, localized carcinomas and malignant papillomas.

Tumors or ulcers of the anterior, lateral and posterior walls and of the vertex of the bladder may be removed by excision. When excising a malignant tumor, a wide margin about the tumor should be removed.

Technique of Excision of Bladder Tumor

The bladder is filled with air and is exposed through a midline suprapubic incision, using great care not to open the peritoneum. After the bladder wall has been separated for some distance from the abdominal incision, the tumor can usually be felt by careful palpation. An opening is made into the bladder through healthy tissue. After carefully determining the extent of the tumor, it is excised with a liberal margin of uninvolved bladder wall. The wound left in the bladder may be irregular, and closure may therefore be difficult. Closure is made with chromic catgut passing through the bladder wall down to the mucosa. All bleeding points are carefully ligated before the abdominal wound is closed.

A drain is placed in the prevesical space, and a retention catheter is left in the bladder.

Tumors in the region of the trigone are treated with the cautery or radium and x-ray. If the bladder is extensively involved with a malignant tumor, it should be treated by implantation of the ureters into the sigmoid or ileal segment followed by cystectomy.

INTRAVESICAL DIVERTICULECTOMY

General Considerations

Bladder diverticula are found in patients having obstruction of the bladder neck or urethra. After removal of the obstruction to the urinary flow, diverticula may remain quiescent and not require treatment. Small diverticula may completely disappear after bladder obstruction has been removed.

Diverticula producing symptoms should be removed by operation. This is particularly true if they harbor infection or stones.

Diverticula may be removed by either extravesical or intravesical excision. Young states that intravesical excision is the operation of choice.

Dangers and Safeguards

Infection of the operative wound may occur with sloughing of tissue and resulting bladder fistula. Young advises extravesical drainage at the site of the excised diverticulum. Operations at the base of the bladder may involve a ureter. There is danger of *wounding or severing a ureter* during the operation. Careful dissection and visualization of structures are necessary to avoid this complication. A severed ureter may be implanted into the bladder, but this procedure frequently results in ascending infection which may necessitate later nephrectomy. When the terminal end of the ureter is

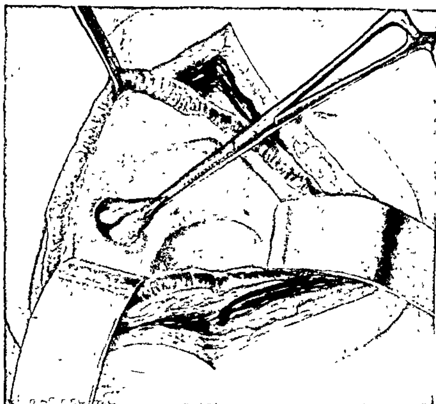


FIGURE 740. Intravesical diverticulectomy. The bladder is widely opened, and exposure is obtained with retractors. The wall of the diverticulum is grasped with a hemostat and gradually drawn into the bladder. (Horsley and Bigger: Operative Surgery, C. V. Mosby Company.)

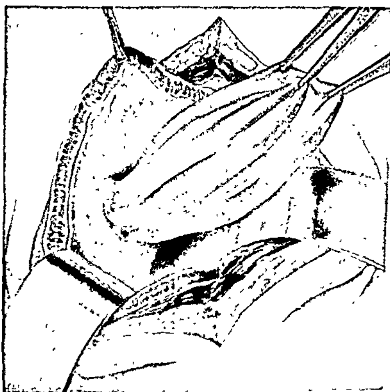


FIGURE 741. Intravesical diverticulectomy (*continued*) The diverticulum has been completely drawn into the bladder. The dotted line around the base indicates the line of incision for its removal. (Horsley and Bigger Operative Surgery, C V. Mosby Company)

involved in the diverticulum, the bladder wall should be reconstructed to relocate the uretral orifice properly. *Constriction of the ureter* may follow operation, requiring later treatment by dilatation. The size and location of the diverticulum should be determined by cystoscopic examination or by cystograms made before operation.

Technique of Operation (Figs. 740 to 743)

With the patient in the Trendelenburg position, the bladder is opened as for cystotomy.

The diverticulum is drawn into the bladder with a hemostat or by means of a glass suction tube as used by Young. If the diverticulum is firmly adherent, extravesical dissection may be necessary to permit its delivery into the bladder. Digital pressure from without while traction is made from within will aid withdrawal of the diverticulum into the bladder. The peritoneum, vas and ureter must be safeguarded during dissection.

When the diverticulum is completely freed and drawn into the bladder, it is

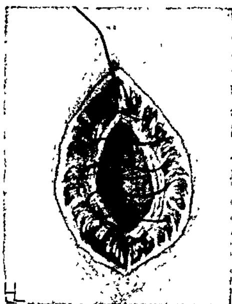


FIGURE 742. Intravesical diverticulectomy (*continued*). After removal of diverticulum the wound is closed with no. 0 chromic catgut sutures. The first row of sutures closes the muscle and fibrous layers of the bladder wall. (Horsley and Bigger: Operative Surgery, C V. Mosby Company.)

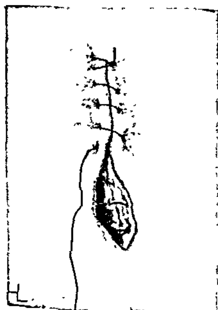


FIGURE 743. Intravesical diverticulectomy (*concluded*). The mucosa and submucosa are closed with fine chromic catgut sutures. (Horsley and Bigger: Operative Surgery, C. V. Mosby Company.)

removed by making an incision about its base. The wound in the bladder wall is closed with two rows of chromic catgut sutures. If the ureter opens into the diverticulum, it should be preserved and restored to position in the bladder wall.

The incision in the bladder is closed with chromic catgut. A tube drain is placed through the upper end of the incision near the peritoneal reflection. The extravesical bed of the resected diverticulum is drained through the prevesical space at the lower end of the abdominal incision. The abdominal wall is closed in layers with chromic catgut or through-and-through wire sutures.

CYSTECTOMY

Indications

Total cystectomy is indicated in exstrophy of the bladder and in selected cases of carcinoma of the bladder following ureteral implantation into the sigmoid colon or ileum or into the skin (ureterostomy). The techniques of ureteral transplant are described elsewhere in this chapter.

Technique of Operation

In the male the bladder may be removed either with or without the prostate, depending upon the indications.

A midline incision above the pubes is made. The bladder is exposed, and its peritoneal covering is carefully dissected off and retracted. All vessels are ligated as the dissection proceeds. The pubovesical ligaments are next divided to further mobilize the bladder. If the ureters have not previously been implanted into the sigmoid, the lower ends are severed and ligated. By making strong traction on the bladder, the vesical neck is exposed and divided. The urethra is ligated or sutured. The bladder is then dissected from the prostate.

If the prostate is to be removed with the bladder, it is separated from the rectum, and the vas on each side is sectioned and ligated. There is danger of entering the peritoneum and rectum if the dissection is not done carefully under direct vision.

All vessels are carefully ligated. The abdominal wound is closed about a drain.

SUPRAPUBIC PROSTATECTOMY

General Considerations

Although transurethral resection of the prostate has definitely reduced the indication for prostatectomy, there are certain cases of prostatic hypertrophy, having large median and lateral lobes, for which operative removal of the prostate by enucleation is the procedure of choice.

Dangers and Safeguards

A careful study of the *physical condition* of every patient who is a candidate for prostatectomy is imperative. Because of the advanced years of most such patients,

cardiac disease, renal impairment, chronic bronchitis, asthma, emphysema and hypertensive cardiovascular disease are common. Prolonged preoperative treatment may be necessary in some cases. With careful preoperative and postoperative therapy the mortality rate of prostatectomy should not exceed 5 per cent.

Patients having urinary retention and impaired renal function should have *preliminary decompression of the bladder* until renal function is restored. Decompression may be obtained by the use of the indwelling catheter or by suprapubic cystostomy. Many surgeons prefer catheter drainage when pain and urethral infection are not serious complications. Catheter drainage avoids the necessity of two operations and permits better surgical exposure of the prostate than does a preliminary cystostomy. When infection is an important problem and the relief of pain is an immediate necessity, suprapubic cystostomy is the treatment of choice.

The chief dangers following operation are *hemorrhage, shock, kidney infection, psychoses, respiratory infections* and *cardiac failure.* Acute epididymitis occurs in about 20 per cent of the cases if a preliminary vasectomy has not been done. More remote and more uncommon complications of prostatectomy are urethral stricture, bladder fistula, incontinence of urine, and loss or impairment of the sexual function.

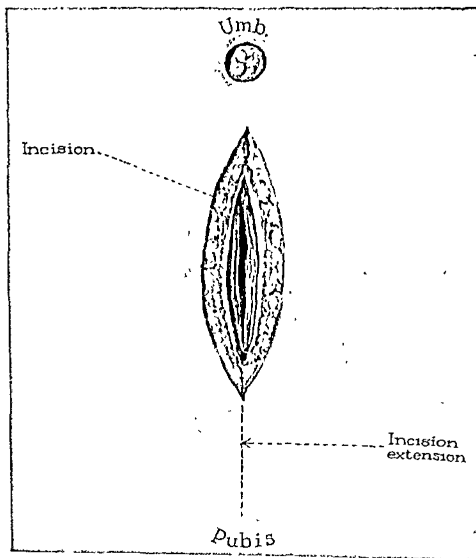


FIGURE 744 Suprapubic prostatectomy. Incision is made high for preliminary cystostomy of the two-stage operation The dotted line indicates the extension of the incision for the second stage. (Kretschmer. Lewis' Practice of Surgery, W F. Prior Co.)

Technique of Operation (Figs. 744 to 751)

The choice of anesthetic must depend upon the general condition of the patient. Spinal or gas anesthesia (ethylene or cyclopropane) is commonly used.

The bladder is thoroughly irrigated and filled with sodium chloride or boric acid solution. A distended bladder is easily exposed.

A suprapubic incision is made in the midline about 10 to 12 cm. long. If a preliminary cystostomy is made as the first stage of a two-stage prostatectomy, the incision should be made some distance from the pubic bone to permit extension of the incision downward through sound tissue when the bladder is opened to remove the prostate. The fascia in the midline is carefully incised to avoid injury to the bladder or peritoneum. The distended bladder is usually readily recognized by palpation and by blood vessels on its wall. To expose the bladder wall, the overlying fat and peritoneal fold are dissected upward with the finger covered with gauze.

After the bladder has been adequately exposed, its wall is grasped with Allis forceps, a trocar is inserted, and the bladder is emptied to prevent wound soiling. At this stage the puncture wound may be enlarged to permit digital exploration if a preliminary cystostomy is to be done. If the prostate is to be immediately removed, the opening in the bladder is made large enough to admit the finger freely for enucleation

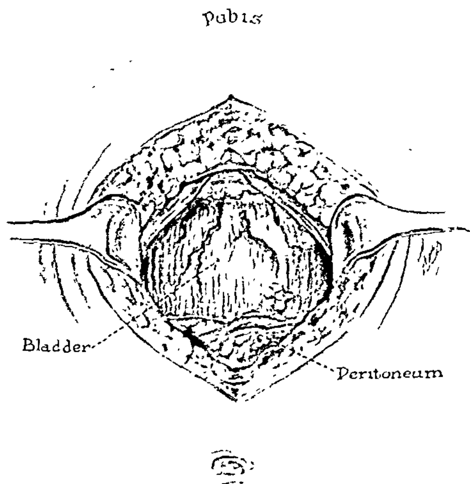


FIGURE 745 Suprapubic prostatectomy (*continued*) The bladder is exposed, showing large vessels and the thickened bladder muscle. (Kretschmer Lewis' Practice of Surgery, W F Prior Co)

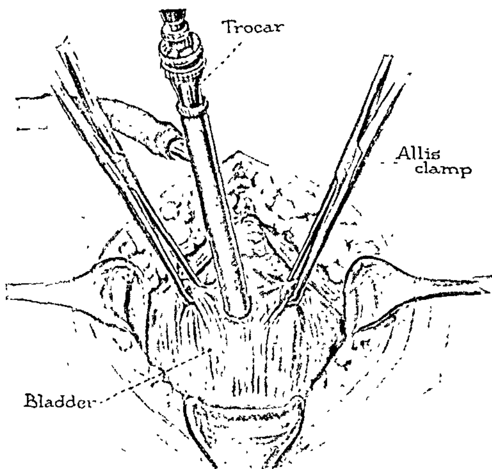


FIGURE 746. Suprapubic prostatectomy (*continued*). The bladder is grasped with Allis clamps. Trocar and suction used to empty the bladder to avoid contamination of the wound (Kretschmer: Lewis' Practice of Surgery, W. F. Prior Co)

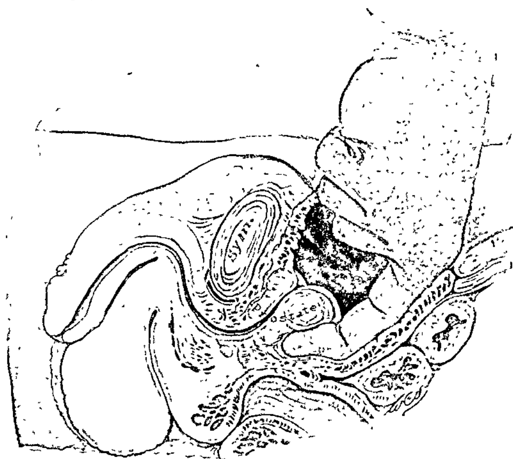


FIGURE 747 Suprapubic prostatectomy (*continued*). Prostate is enucleated with the finger. (Kretschmer: Lewis' Practice of Surgery, W. F. Prior Co)

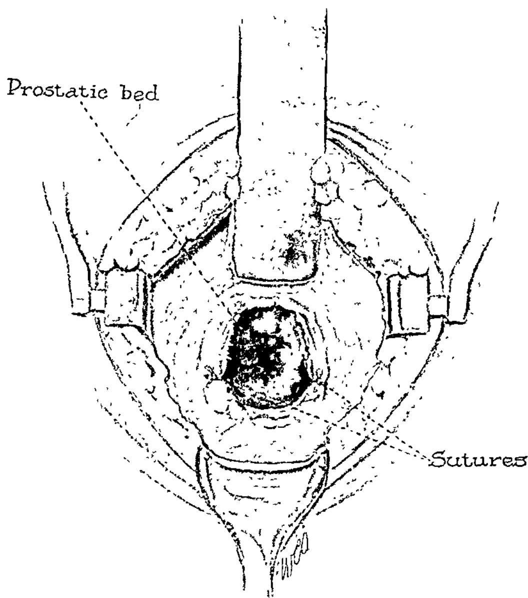


FIGURE 748. Suprapubic prostatectomy (*continued*). The edges of the prostatic capsule have been trimmed, and the vessels have been ligated by placing sutures (Kretschmer. Lewis' Practice of Surgery, W F. Prior Co.)

of the prostate. To remove the prostate under vision, a large incision is made in the bladder, and the wound is held open with self-retaining retractors.

The prostate may be removed by the sense of touch, either by inserting the tip of the finger into the urethral orifice and dissecting outward around the prostatic lobes, or by first incising the mucous membrane over the most prominent part of the prostate and, after finding a line of cleavage, enucleating each lobe in turn by careful finger dissection. Finger enucleation may be facilitated by inserting one or two fingers of the left hand into the rectum to elevate and immobilize the prostate and bladder neck.

If the prostate is to be removed under vision, an incision is made through the mucosa; through this incision the line of cleavage is found by blunt dissection with scissors or finger The enucleation is then made as described above. By this method bleeding vessels are easily located and ligated, tags of mucous membrane can be excised, and small nodules of adenomatous tissue may be seen and removed.

If a two-stage operation is to be done, the second stage should follow the first as soon as the general condition of the patient will permit. The primary wound may be opened and enlarged if too much time has not elapsed between operations. When the wound is well healed, an incision is made in the scar and extended down to the pubes. The prostate is enucleated as described above.

Any hemorrhage should be controlled during the operation. Control may be accomplished by suture, rubber bag or gauze packs. Sutures may be passed through tissues about bleeding vessels and tied. A distended rubber bag is useful when sutures cannot be applied or fail to stop the bleeding. Gelfoam applied to the prostate bed is

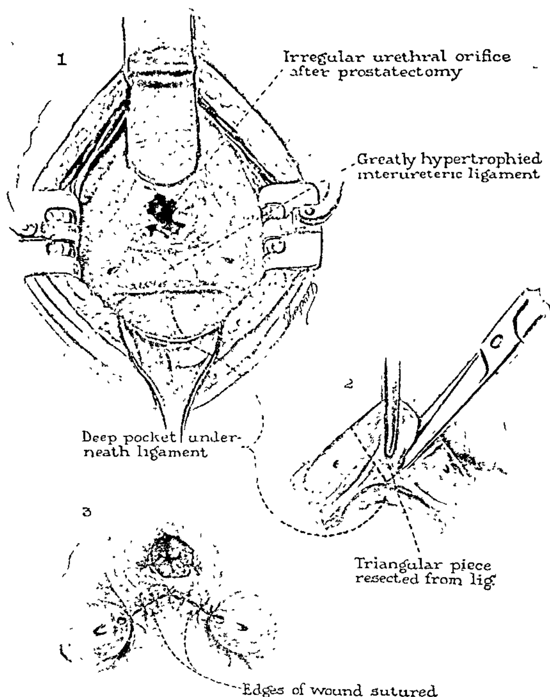


FIGURE 749 Suprapubic prostatectomy (*continued*). *1*, Irregular urethral orifice after prostatectomy and a greatly hypertrophied interureteric ligament. *2*, Interureteric ligament is resected *3*, Edges of prostatic capsule have been trimmed and sutures placed to control bleeding. Wound in interureteric ligament sutured (Kretschmer· Lewis' Practice of Surgery, W. F. Prior Co.)

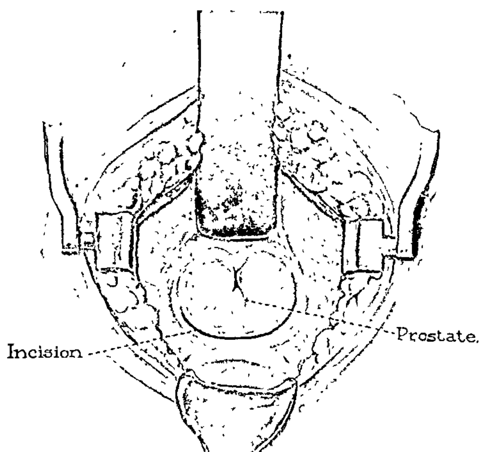


FIGURE 750 Suprapubic prostatectomy (*continued*). Location of incision in mucous membrane when the prostate is to be removed under direct vision. (Kretschmer Lewis' Practice of Surgery, W F. Prior Co.)

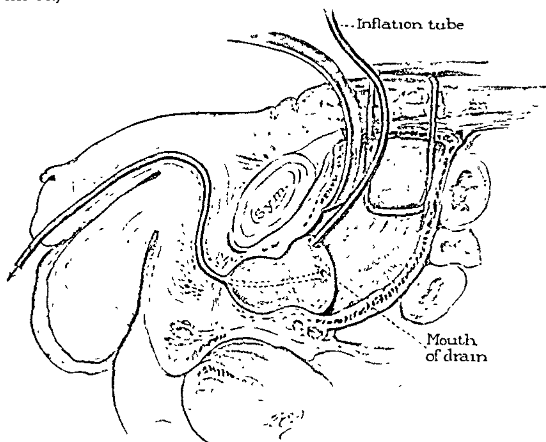


FIGURE 751. Suprapubic prostatectomy (*concluded*) A distended hemostatic bag in place in the prostatic bed. (Kretschmer: Lewis' Practice of Surgery, W. F. Prior Co.)

helpful in controlling oozing. A gauze pack will efficiently control bleeding and is always available. The hemostatic bag or gauze pack may usually be removed in twelve to twenty-four hours.

REPAIR OF ENTEROVESICAL FISTULA

General Considerations

A fistulous communication between the bladder and bowel is uncommon but not rare. The cause is usually trauma, infection or neoplastic disease. Diverticulitis of the sigmoid, with perforation and abscess formation against the bladder wall, may cause a persistent fistula.

Technique of Operation

A fistula between the small intestine and bladder can usually be closed by abdominal operation. By careful dissection the bowel and bladder are separated and closed with a double row of sutures. Excision of a segment of the intestine may be necessary in some cases.

Closure of an opening between the bladder and rectum may be technically difficult and frequently will be unsuccessful unless preceded by a colostomy to defunctionalize the lower sigmoid and rectum. When there is much destruction of the rectal wall, resection and an anastomosis may be indicated.

After closure of an enterovesical fistula the bladder should be drained by a retention catheter or suprapubic cystostomy.

Operations for enterovesical fistulas caused by carcinoma or tuberculosis are of doubtful value. In selected cases the site of the primary disease in the bladder or bowel may be resected as a part of an extensive removal of the disease. The final results of such operations hardly justify such treatment.

OPERATIONS UPON THE URETER

URETEROURETEROSTOMY

General Considerations

The ureters may be injured by penetrating wounds of the abdomen. Such wounds, however, are not common even in wartime. Injuries to the ureters may occur during operations upon the pelvic organs or upon the sigmoid colon and rectum. It is imperative that wounds of the ureters be promptly repaired to prevent extravasation of urine into the peritoneal cavity followed by peritonitis. Ligation or severance of both ureters, unless promptly treated, will result in uremia and death.

When a ureter is inadvertently divided during abdominal or pelvic operations, several possibilities remain. Many techniques have been devised for reanastomosing the cut ends, and the fact that so many techniques have been described is good evidence that none is entirely satisfactory. Although immediate results following these procedures are often good, as healing occurs there is an inevitable stricture formation requiring subsequent dilatations and in most instances an obstructive hydroureter and

pyelonephritis above the site of stricture. If the site of division is low, reimplantation of the proximal end of the ureter into the bladder is much more satisfactory than reanastomosis. Permanent ligation of the ureter will result in atrophy of the kidney without infection in most instances and has been advocated as the procedure of choice by some surgeons when the ureter is divided. This may necessitate nephrectomy at a later date. Implantation of the proximal end of the divided ureter into bowel or into the opposite ureter has also been advocated. By all odds the most effective method is preventative, and careful visualization of the ureters during dissection in the abdomen and pelvis to avoid their injury is the only certain way of avoiding serious consequences. The placement of catheters in the ureters before operation simplifies identification during the operation.

Technique of Operation

If the ureter has been severed without loss of a segment, it may be united by anastomosis. If a section of the ureter is lost, anastomosis may be successful if the ends can be united without tension.

End-to-end anastomosis (Fig. 752) may be made over a ureteral catheter. If ureteral catheterization cannot be done during the operation, a ureteral catheter may be passed retrograde into the bladder and later withdrawn through the urethra with a cystoscope. The catheter is inserted to the pelvis of the kidney and left in place for

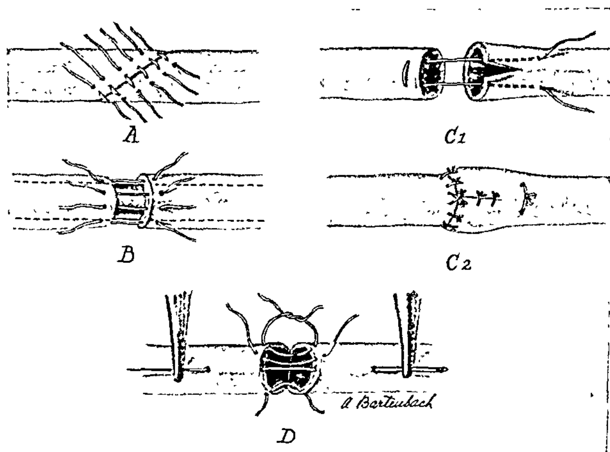


FIGURE 752 Methods of ureteral anastomosis. *A*, Oblique section of ureter. Severed ends united with interrupted Lembert sutures *B*, End-to-end anastomosis over a catheter C_1 and C_2, Anastomosis by invagination. *D*, Payne's method of end-to-end anastomosis A sewing needle is used for fixation while interrupted fine chromic catgut sutures are placed.

eight to ten days. Very fine silk is used for sutures. The sutures should be placed close together and should not penetrate the lumen of the ureter. Fine catgut should be used if the stitches penetrate the ureteral lumen. A simple method of ureteral fixation with a needle has been used by Payne to facilitate end-to-end suture (Fig. 752).

Oblique end-to-end anastomosis (Fig. 752) may be done with or without an intraureteral support. The ends are carefully cut to fit, and, while held by two anchor sutures, one placed opposite the other, the ends are united with carefully placed interrupted sutures of fine silk. The sutures should not penetrate the lumen of the ureter.

Anastomosis by invagination (Fig. 752) is another method of ureteroureterostomy. One end of the ureter is dilated and slit, and into this end the opposite end is drawn and sutured. A fine plain catgut suture is passed outward through the posterior wall of one end and outward through the posterior wall of the slit segment about 1 cm. from the end. One end is drawn into the other and held by tying the catgut suture. The anastomosis is then completed with fine interrupted silk sutures.

EXTRAPERITONEAL REMOVAL OF URETERAL STONE (URETEROLITHOTOMY)

General Considerations

Many small ureteral stones will pass spontaneously, and others may be removed by manipulation through a cystoscope. The condition of the patient, the condition of the kidney, and the location and size of the stone are factors which must be considered before operative treatment is instituted. In general, a stone larger than 1 cm. in diameter requires operative removal. Regardless of the size of a stone fixed in the ureter, expectant treatment or manipulative measures should not be prolonged if the patient is toxic from infection or if progressive kidney damage is evident.

Stones may become impacted in the upper, middle and lower thirds of the ureter. The type of operation varies with the location of the stone. The extraperitoneal exposure of the ureter is the method of choice.

Technique of Operation

A stone in the *upper third* of the ureter is exposed through a low kidney incision. The fascia and fatty capsule of the kidney are divided to expose the lower kidney pole. By retraction of the kidney upward, the ureteropelvic junction can usually be readily freed by blunt dissection and visualized. Palpation will aid in the identification of the ureter. The spermatic or ovarian vessels lie near the upper ureter and must be identified and protected. A tape passed about the exposed ureter will aid in its control.

The stone is located by palpation and removed through a longitudinal incision at or just above its point of impaction The wound in the ureter is closed with fine chromic catgut. The sutures should not penetrate the lumen of the ureter.

A stone in the *middle third* of the ureter can usually be exposed through a low kidney incision. If this exposure is inadequate, the incision may be extended downward and medial to the anterior-superior spine. A stone located at the pelvic brim may, in some cases, be dislodged upward, making removal easier.

The *lower third* of the ureter may be exposed through a lower abdominal oblique incision or a low rectus incision (Fig. 753). The peritoneum should not be opened. The peritoneum is dissected from the abdominal and pelvic walls until the ureter is exposed. The ureter lies just beneath the peritoneum and can easily be freed by blunt dissection. A tape is passed around the ureter for traction. When possible, a low-lying stone should be manipulated upward in the ureter to make removal easier. If the stone is impacted in the terminal portion of the ureter, exposure and removal may be difficult. In the female the ureter passes beneath the broad ligament and tube; and inflammation or tumors of the pelvic organs may greatly increase the difficulties of exposure of the terminal portion of the ureter. In the male the vas deferens crosses the ureter anteriorly near the bladder.

After the ureter has been freed, it is lifted and held taut by traction tapes to facilitate incision and extraction of the calculus and later repair (Fig. 754).

The wound in the ureter is closed with fine catgut sutures carefully inserted to avoid penetrating the ureteral lumen. A drain is placed in the extraperitoneal tissues near, but not in direct contact with, the suture line. The fascia and muscle are closed in layers with catgut and the skin with silk.

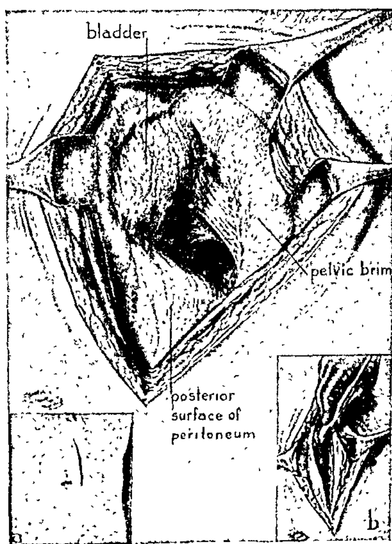


FIGURE 753 Extraperitoneal ureterolithotomy *a*, *b*, Incision through the right rectus muscle near its outer margin down to the peritoneum. The peritoneum is stripped from the lateral abdominal wall and right side of the bladder This exposes the lateral ligaments of the bladder, which are incised to expose the terminal end of the ureter. (Young's Practice of Urology.)



FIGURE 754 Extraperitoneal ureterolithotomy (*continued*). The lower end of the ureter is exposed and lifted with clamp *a*, Ureter freed and held up by tape. Incision is made over the stone. *b*, Ureter opened, showing stone and ureteral catheter. *c*, The ureter is closed with fine chromic catgut sutures which do not penetrate the ureteral lumen (Young's Practice of Urology.)

A stone impacted in the distal end of the ureter may protrude into the bladder. If such a stone cannot be removed by incision through a cystoscope, a suprapubic cystotomy may be advisable. When the latter is necessary, an incision through the mucosa of the ureterovesical junction upward from the ureteral orifice will permit easy extraction of the stone.

IMPLANTATION OF URETER INTO BLADDER

General Considerations

The *indications* for implantation of a ureter into the bladder are partial resection of the bladder, trauma of the ureter which cannot be repaired by other methods, and strictures of the lower end of the ureter which cannot be successfully treated by other means.

Implantation of the ureter into the bladder is usually successful if the technique of the operation has not been faulty. The first operation here described is essentially

the same as that used by Hinman in his experimental studies and applied clinically by Wharton. A simple method described by Payne has also proved successful.

Technique of Operation (Fig. 755)

A midline or paramedian lower abdominal incision is made. The patient is placed in the Trendelenburg position, and the intestines are packed well out of the field.

Both ureters may be implanted in the bladder at the same time if indicated. The pelvic ureter is mobilized down to the bladder, ligated near the bladder, and divided. The preparation of the ureter for bladder implantation is the same as that used for ureterointestinal implantation as described elsewhere in this chapter. To prevent wound soiling, a no. 8 or 9 catheter is fixed in the end of the ureter with a ligature.

A portion of the bladder covered with peritoneum is fixed with stay sutures. Between these sutures an incision is made through the peritoneum and muscular wall of the bladder down to the mucosa. The catheter is removed from the ureter, and the end is slit to ensure patency. A small puncture wound is then made through the mucosa, and through this opening the end of the ureter is passed. The submucosa is sutured to the wall of the ureter without penetrating or distorting its lumen. The bladder wall is closed, implanting the ureter in an oblique position. This is done with a few sutures of fine chromic catgut carefully placed to avoid constriction of the ureter. When possible, without kinking the ureter, it is wise to peritonealize the exposed ureter and site of anastomosis.

The wound is closed without drainage.

After the operation a retention catheter is placed in the bladder, where it is left eight to ten days. The bladder is irrigated twice daily with 200 to 300 cc. of boric acid solution. A sulfonamide may be given as a preventive measure.

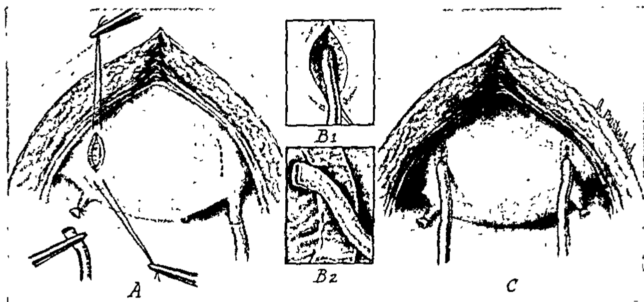


FIGURE 755 Implantation of ureters into the bladder. *A*, Incision made in bladder wall down to the submucosa between traction sutures B_1, End of ureter passed into bladder and fixed with 3 sutures which unite the submucosa of the bladder and the adventitia of the ureter. B_2, Ureter in oblique position in bladder wall *C*, Implantation of both ureters completed (Redrawn from Weyrauch, Burns, Peterfy and Hinman Surg, Gynec & Obst.)

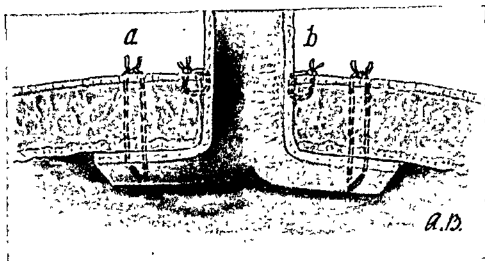


FIGURE 756. Implantation of ureter into bladder Section drawing shows method of suturing split ureter into bladder wall. (Redrawn from Payne: J.A.M.A , Vol. 51.)

Technique of Operation (Payne) (Fig. 756)

The ureter is approached and freed extraperitoneally. If the ureter is too short to reach the bladder without tension, the bladder is separated from its attachments, elongated upward, and fixed to the pelvic fascia. If necessary, the kidney may be mobilized to reduce the tension on the ureter.

The end of the ureter is bisected a distance of about 1 cm. Into each half of the bisected ureter a chromic catgut suture is passed, and each end of the suture is threaded on a curved needle. An opening is then made in the bladder wall just large enough for the passage of the ureter without constriction The needles are passed through the opening and out through the bladder wall on each side. When these sutures are tied, the end of the ureter is drawn through the wound and fixed to the bladder wall. Additional interrupted sutures of fine chromic catgut are used to fix the ureteral wall to the bladder wall. Sutures should not penetrate the lumen of the ureter and should not constrict or distort the ureter.

IMPLANTATION OF URETERS INTO SIGMOID COLON

General Considerations

The *chief indications* for implantation of the ureters into the rectosigmoid or sigmoid are exstrophy of the bladder and carcinoma of the bladder. This operation may also be indicated in selected cases of bladder tuberculosis and in cases of large incurable vesicovaginal fistulas.

After ureteral implantation for exstrophy and carcinoma of the bladder, complete cystectomy is usually indicated. The operation may be done in one stage or in two stages, depending upon the status of the patient. The ultimate results of this operation are good if no serious complications develop. The rectum acts as a reservoir for the urine, which may require emptying two or three times at night and four or five times during the day. Rectal tolerance increases with time.

Several different techniques of ureterosigmoid anastomosis have been devised. The use of a bowel wall tunnel as exemplified by the Coffey no. 1 technique (Fig.

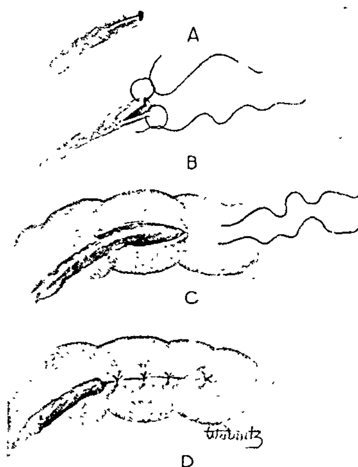


FIGURE 757. Ureterosigmoidostomy by the Coffey no 1 technique, utilizing a bowel-wall tunnel (T. D. Moore, in Campbell: Urology)

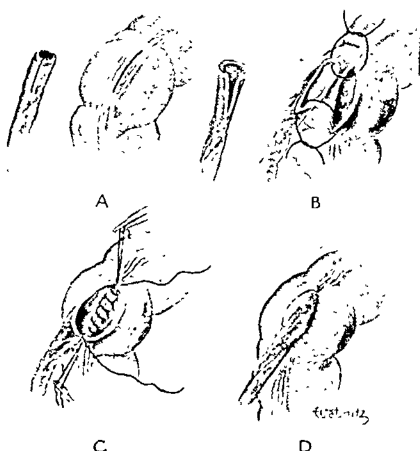


FIGURE 758 Ureterosigmoidostomy using the mucosa-to-mucosa technique of Nesbit (T. D Moore, in Campbell: Urology)

757) helps prevent reflux into the ureter, but does tend to develop stricture, whereas the mucosa-to-mucosa technique as described by Nesbit and others (Fig. 758) is attended with fewer postoperative strictures, but does not prevent reflux of colon contents into the ureter.

Dangers and Safeguards

The dangers of implantation of the ureters into the sigmoid are many. Young patients tolerate the operation better than those advanced in years. The general condition of the patient at the time of operation is a factor in both morbidity and mortality. The physical fitness of patients with carcinoma is likely to be more impaired than those having more benign conditions.

A careful preoperative estimation of the kidney function should be made. Thorough preparation of the bowel with antibiotics as well as mechanical cleansing is done before operation.

Spinal anesthesia gives the best exposure of the operative field. A retention catheter will keep the bladder empty and out of the way during the operation. Adequate abdominal exposure is essential in the prevention of errors in technique.

The immediate dangers of the operation are shock and local soiling of the wound by intestinal contents. Postoperative complications caused directly by the operation may be peritonitis and ascending urinary tract infection. Stricture may develop at the site of implantation if the ureter is constricted by ill-advised suturing of the bowel wall.

Gross regards the following principles of fundamental importance in the success of ureterocolonic anastomosis: (1) simplification of technique; (2) a transabdominal exposure; (3) establishment of a long, intramural, submuscular implantation of the ureter; (4) the projection into the lumen of the bowel of only a short segment of ureter to minimize subsequent scarring and obstruction; (5) adequate anchorage of the ureter in the tunnel, (6) leaving a small ureteral catheter in place during anastomosis to ensure adequate lumen; and (7) transplantation of the ureters in separate stages.

Technique of Operation (Figs. 759 to 764)

The technique of ureteral implantation into the colon was developed by Dr. R. C. Coffey. Many techniques, based upon the work of Coffey, have been recorded, some of which are too intricate and elaborate to be practical. The technique here described has been successfully used by Hinman. This technique is essentially the same as that used by Ladd and Lanman at the Boston Children's Hospital and by Wharton at the Johns Hopkins Hospital.

The series of drawings illustrating the technique of ureterointestinal anastomosis shows the implantation of the left ureter into the sigmoid. As a rule, the right ureter is implanted first at as low a level as possible. The left ureter is then implanted into the sigmoid at a slightly higher level.

A high Trendelenburg position is advised to give maximum exposure. A low right rectus or paramedian incision is used. The technique of ureteral implantation is identical on both sides.

Step 1. The ureter is exposed by reflecting a peritoneal flap outward from the



FIGURE 759. Implantation of ureters into sigmoid A peritoneal flap has been dissected up to expose the ureter. Near the bladder the ureter has been exposed and clamped for section and ligation. (Hinman: Surg, Gynec. & Obst., Vol. 61. By permission of Surgery, Gynecology and Obstetrics.)



FIGURE 760. Implantation of ureters into sigmoid (*continued*) A favorable site for implantation is selected The line for incision into the bowel wall is indicated by the broken line beneath the ureter marked by stay sutures. (Hinman Surg., Gynec. & Obst., Vol. 61. By permission of Surgery, Gynecology and Obstetrics.)



FIGURE 761. Implantation of ureters into sigmoid (*continued*) Drawing to illustrate the manner in which the 3 anchoring sutures are placed. *a*, Suture no 1 is passed from left to right through the submucosa, and right to left through the adventitia of the ureter. *b*, Suture no 2 is passed in the same manner opposite no. 1. *c*, Sketch to show how sutures are placed in the submucosa. *d*, Suture no. 3 is placed in the submucosa at the extreme lower end of the incision, forming a triangle of the 3 sutures. Sutures must not penetrate the lumen of the bowel or ureter (Hinman: Surg , Gynec. & Obst., Vol. 61 By permission of Surgery, Gynecology and Obstetrics)

sigmoid and dissecting it free from below the pelvic brim down to the bladder, where it is sectioned, and the lower end is ligated. The upper end of the ureter is ligated to prevent leakage of urine. Stay sutures are placed in the intestinal wall to fix it. An incision is made through the serosa and muscle layers down to the submucosa. This incision may be made in a taenia or may be placed lateral to the taenia nearer the ureter. The line of incision must be so placed that it will lie directly in the line of the ureter to prevent kinking The ureter must be implanted without tension.

Step 2 A plane of cleavage is found between the muscle and submucosa, and flaps are raised to produce a bed of sufficient width to prevent compression of the

ureter when the wound is closed. This dissection should be done with great care to prevent perforation of the intestine.

Step 3. Three anchor sutures are placed at the lower end of the incision in the sigmoid. Two of these sutures pass through the adventitia of the ureter and through the submucosa on each side of the lower portion of the incision. The third suture is placed in the submucosa at the lower end of the incision. The three sutures outline a triangle of submucosa in the lower end of the incision.



FIGURE 762. Implantation of ureters into sigmoid (*continued*) A hole is made through the mucosa in the triangle marked by the 3 sutures. Through a slit in the wall of the ureter near the end a probe is passed to hold the ureter rigid for insertion into the bowel. (Hinman· Surg, Gynec. & Obst., Vol. 61. By permission of Surgery, Gynecology and Obstetrics.)

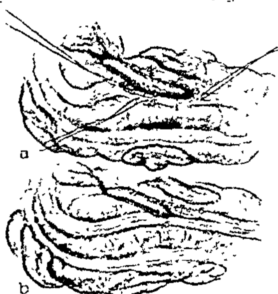


FIGURE 763. Implantation of ureters into sigmoid (*continued*) Sutures 4 and 5 are placed to hold the ureter in the muscular trough Sutures 6 and 7 close the serous and muscular layers over the ureter The ureter must not be constricted by these sutures (Hinman. Surg., Gynec & Obst., Vol. 61 By permission of Surgery, Gynecology and Obstetrics)

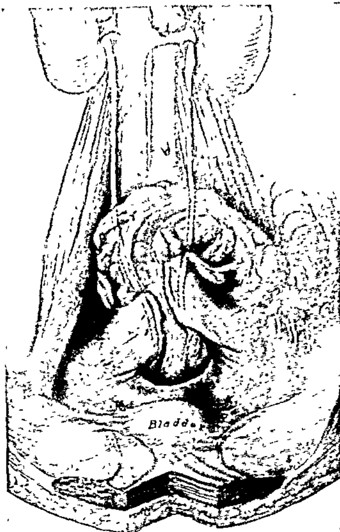


FIGURE 764. Implantation of ureters into sigmoid (*concluded*). The operative field is carefully peritonealized with folds of pelvic peritoneum. (Hinman: Surg., Gynec. & Obst., Vol. 61 By permission of Surgery, Gynecology and Obstetrics)

Step 4. An opening is made with a cautery (or knife) through the mucosa at the base of the triangle formed by the three sutures described above. A slit is made in the lower end of the ureter proximal to the ligature, and through this slit a probe is passed to guide the lower end of the ureter into the bowel. The slit in the ureter is left open for passage of urine. The three sutures are carefully tied to avoid constriction of the ureter.

Step 5. Two sutures (the fourth and fifth) are used to anchor the ureter in the upper part of the muscular channel in the sigmoid wall. The serous and muscular layers of the wound are closed over the ureter with two additional sutures (the sixth and seventh).

Step 6. When the implantation of the ureters is completed, the operative wounds in the sigmoid are carefully covered with flaps of peritoneum. Care is taken that the ureters are not angulated during this step.

After operation a tube is left in the rectum for eight to ten days for drainage of urine. A low residue diet is given until the tube is removed.

CONSTRUCTION OF AN ILEAL BLADDER

General Considerations

During recent years Bricker has devised and successfully utilized the procedure of implanting the ureters into an isolated segment of ileum to act as a substitute for

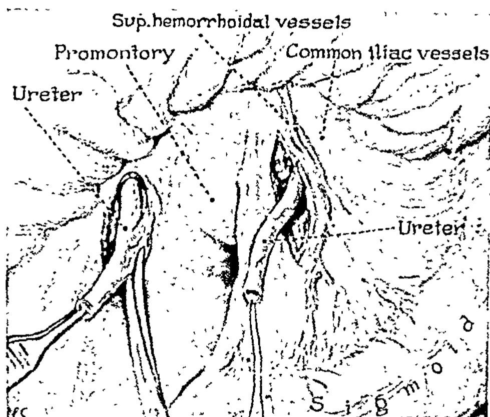


Fig. 765.

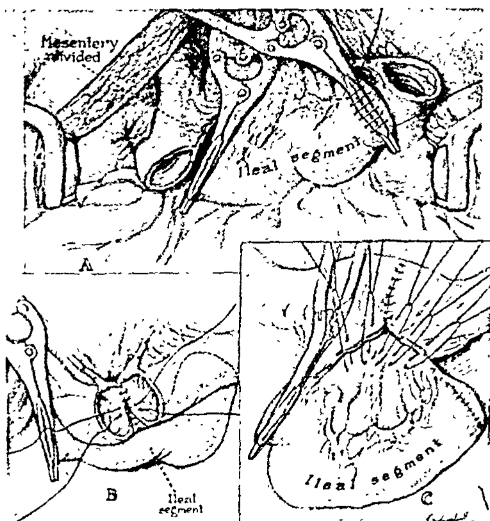


Fig. 766.

the urinary bladder after exenteration of the pelvic viscera or the removal of the urinary bladder for other reasons. Since this segment is isolated from the fecal stream, the incidence of retrograde infection and stricture formation at the site of anastomosis has been low. The isolated ileal segment evacuates promptly by its own peristaltic action and does not serve as a reservoir. Because of its size, the absorption of urinary constituents is of no clinical significance.

Before operation the bowel is cleaned mechanically and intestinal antibiotics are administered.

Technique of Operation (Bricker) (Figs. 765 to 769)

The approach and the technique vary slightly, depending upon the location and extent of disease for which the procedure is being carried out. If the rectum and sigmoid are not removed, the left ureter is exposed through the lateral peritoneal re-

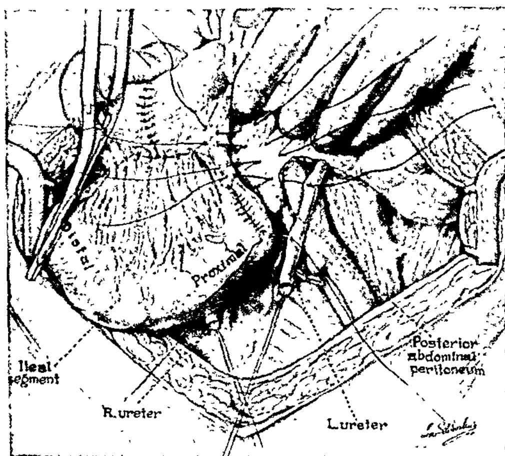


FIGURE 767 Ileal bladder (*continued*). Anastomosis of the left ureter to the ileal segment leaves a tunnel formed by the ureter, the segment and the inferior surface of the mesentery. This tunnel is obliterated by closing the space, as here indicated Because the right ureter lies posterior, closure of this potential space is not necessary (E. M. Bricker. S. Clin North America, Vol. 36.)

FIGURE 765. Ileal bladder The ureters have been divided approximately 3 cm. distal to the iliac vessels and the terminal portion mobilized When the colon is not removed, as here illustrated, the left ureter is passed through an incision in the mesentery of the sigmoid passing beneath the superior hemorrhoidal artery. Care must be taken to avoid angulation of the ureters. (E. M. Bricker: S. Clin. North America, Vol 36)

FIGURE 766. Ileal bladder (*continued*) *A*, Segment of terminal ileum is isolated and the proximal end closed with a double layer of interrupted sutures. *B*, Intestinal continuity re-established by an end-to-end anastomosis anterior to the isolated segment. *C*, The resultant rent in the mesentery is closed. (E. M. Bricker: S Clin North America, Vol 36.)

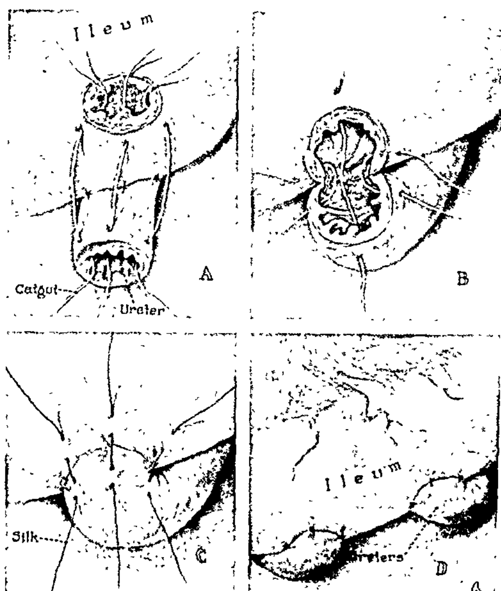


FIGURE 768 Ileal bladder (*continued*) Detail of the mucosa-to-mucosa anastomosis. Stitches of fine chromic catgut through all layers constitute the inner row of sutures. An outer reinforcing layer of silk sutures which do not penetrate the lumen is used The anastomoses are made about 1 or 2 cm. apart and are placed near the blind end of the ileal segment. (E. M. Bricker. S. Clin North America, Vol. 36)

flection, divided approximately 2 to 3 cm. below the iliac artery and transferred *medially through the mesosigmoid beneath the superior hemorrhoidal artery.* Care must be taken to avoid angulation of the ureter. The right ureter can be approached directly through the posterior peritoneum and divided about 2 or 3 cm. below the iliac artery. Care must be taken in mobilizing the ureters to leave an adequate amount of adventitial tissue to ensure adequate vascularity. A segment of terminal ileum approximately 6 to 7 inches in length is then isolated, the distal division usually being 4 to 5 inches from the cecum. Intestinal continuity is then re-established by doing an end-to-end anastomosis. The resulting rent in the mesentery is then closed, taking *care not to jeopardize the blood supply. The proximal end of the isolated segment* is then closed with a double inverting suture. Approximation of the left ureter to the segment leaves a tunnel formed by the ureter, the segment and the inferior surface of the mesentery of the small intestine. This must be obliterated by sutures to avoid

herniation of a loop of small intestine through this area. Since the window formed by the right ureteral anastomosis is smaller and lies posterior, it is not necessary to do such a closure.

A mucosa-to-mucosa anastomosis is then made between the cut ends of the ureter and an opening in the ileal segment. Fine chromic catgut on an atraumatic needle is used, each anastomosis requiring six to eight sutures. This is then reinforced with a second row of fine silk sutures placed between the adventitia of the ureter and the serosa of the bowel, care being taken to turn in as little ureter as possible and not to penetrate the ureteral lumen. Both ureters are anastomosed near the blind end of the segment so that kinking of the segment will not occur with resultant impairment of emptying. The distal end of the segment is then brought out through a small incision in the right lower quadrant, the site having previously been chosen to accommodate an ileostomy bag. Care must be taken not to disrupt any of the previously placed suture lines. A circular piece of skin 1 inch in diameter is excised at the stomal site, and the stoma is sutured to the skin, using interrupted 000 chromic catgut sutures.

The appendix is removed as a prophylactic measure and to simplify the evaluation of subsequent abdominal symptoms. In certain patients with an unusually low-hanging cecum, construction of the stoma in this fashion may produce angulation of the terminal ileum. If this does occur, it may be necessary to incise the lateral peri-

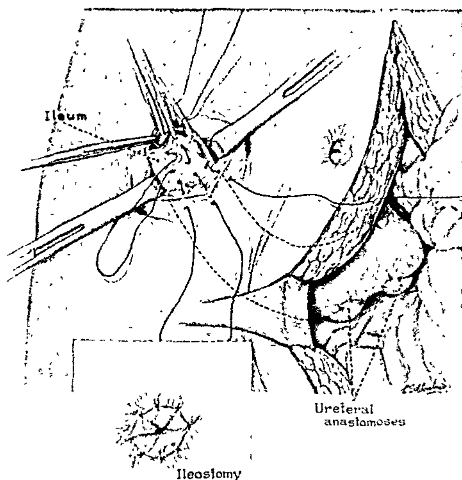


FIGURE 769. Ileal bladder (*concluded*) The distal end of the isolated ileal segment is brought out through a small incision in the right lower quadrant, and the stoma is sutured to the skin edges, as indicated in the inset (E. M Bricker: S. Clin North America, Vol 36)

toneal reflection of the cecum and bring the distal end of the segment through the abdominal wall lateral to the cecum.

Postoperative care in general is similar to that given any patient having major abdominal surgery. Nasogastric suction is used for four to five days to prevent distention. A bag of the Rutzen type is applied to the ileal stoma, taking care to protect the *skin against excoriation.*

URETERECTOMY

Indications

Partial or complete removal of the ureter may be indicated for tuberculosis, malignant tumor, or pyoureter. In nephrectomy for tuberculosis of the kidney and ureter it is frequently safer not to disturb the lower ureter. If sectioned, the tuberculous ureter should be drained. If a fistula forms, a later ureterectomy may be advisable. The lower portion of a pyoureter will often heal after nephrectomy, but if infection persists, ureterectomy is indicated. When carcinoma of the kidney also involves the ureter, the ureter should be resected well below the tumor infiltration when the kidney is removed.

Technique of Operation

Primary excision of the ureter may be done with nephrectomy by extending the kidney incision downward medial to the anterior-superior spine.

When a secondary operation is indicated for the removal of the lower ureter, exposure may be obtained through the same type of incision used to excise a ureteral *calculus (see Extraperitoneal Removal of Ureteral Stone).*

As the ureter is carefully dissected free through its entire length down to the bladder, one must use great care not to enter the peritoneal cavity. If tuberculous, the ureter is sectioned at the bladder and inverted with a purse-string suture, or a small section of the bladder wall is excised and closed with sutures. A pyoureter may be securely ligated at its insertion into the bladder and sectioned. Drainage is usually necessary.

EXTERNAL URETEROSTOMY

Transplantation of the ureter to the skin is indicated in selected cases of carcinoma or tuberculosis involving the bladder and lower ureter and occasionally for intolerable bladder pain.

Technique of Operation

An oblique anterior abdominal wall incision is made about 3 cm. medial to the anterior superior spine The external oblique is divided parallel with its fibers, and the internal oblique and transversalis muscles are cut across to expose the peritoneum. The peritoneum is dissected medially until the ureter is exposed. After freeing the lower end of the ureter, it is ligated and divided between the ligature and a clamp. The ovarian or spermatic vessels are preserved. After separating the ureter up along

the lumbar gutter, it is brought out through the incision, and the wall is sutured to the skin. It must pass from the abdomen obliquely to afford good drainage. The wound is closed loosely about the ureter.

The protruding portion of the ureter sloughs down to the skin. As after-care a catheter may be passed into the ureter up to the kidney to be changed as often as necessary. The catheter may be attached to a urinal fixed to the thigh.

OPERATIONS UPON THE KIDNEY

NEPHRECTOMY

General Considerations

The *indications* for nephrectomy are severe kidney trauma, tuberculosis, tumors, extensive chronic or acute infection with destruction of the kidney, large calculi which cannot be removed successfully without removal of the kidney, certain cases of ectopic kidney and selected cases of hydronephrosis.

Extraperitoneal lumbar nephrectomy is usually the *operation of choice*, although the habitus of the patient and the size and location of the kidney to be removed may indicate use of other types of incisions (Fig. 770). Transperitoneal nephrectomy may be indicated for large tumors of the kidney and ectopic kidney. In such cases the kidney may be approached through an incision made at the outer margin of the

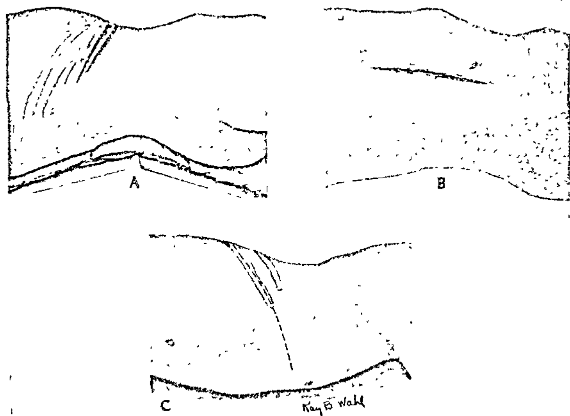


FIGURE 770. Incisions most commonly used for operations upon the kidney *A*, Extraperitoneal, lumbar incision, suitable for most procedures The twelfth rib may be removed to increase exposure. *B*, Transperitoneal incision, suitable for large tumors or ectopic kidney *C*, Combined thoracoabdominal incision, useful for removing large tumors or when there is diaphragmatic attachment. This incision provides excellent exposure of the kidney pedicle

rectus muscle or by a transverse abdominal incision extending medially from the lumbar area. A combination of the rectus and transverse incisions may be used. In rare cases, with extensive fibrosis of the perirenal tissues, intracapsular nephrectomy may be done. In the intracapsular operation the true capsule of the kidney is dissected off and the pedicle carefully ligated. Isolating the pedicle is difficult because of the surrounding dense fibrous tissue.

Dangers and Safeguards

Before removing a kidney *the presence and proper function of the other kidney must be assured.* If there is doubt about the function of the other kidney, the operation should be postponed for treatment and observation except in cases of dire emergency.

Good exposure of the operative field must be obtained to permit identification of all structures. Blind dissection, either blunt or sharp, and excessive traction on the kidney or ureter may result in tearing of important vessels and uncontrollable bleeding. The incision in the abdominal wall should be enlarged, when necessary, to suit the individual case. The *position of the patient* on the table is important for proper exposure of the kidney. *The patient should be placed on the table and fixed in position* before the operation begins (Fig. 771). By placing a cushion or elevator beneath the sound side or by angulating the operating table, the maximum space between the costal margin and iliac crest may be obtained.

As the incision is made, the lower margin of the pleura beneath the twelfth rib must be avoided, the peritoneum should not be torn or incised, and the iliohypogastric and ilio-inguinal nerves should not be injured. As the dissection progresses, aberrant vessels should be recognized, clamped and ligated.

The gravest dangers are *injuries to the duodenum, vena cava and kidney pedicle.* On the right the renal vein is shorter than on the left, and when it is torn by undue traction or careless dissection, uncontrollable hemorrhage may result. Wounds of the vena cava will result in death from hemorrhage unless immediately controlled. Such wounds of the vena cava may be closed by suture after temporary control of bleeding by digital pressure. It is usually much easier to avoid than to repair the blood vessel injuries here noted. Wounds of the duodenum may result in serious infection or duodenal fistula. The latter, if not promptly remedied, will result in death in a few days from loss of duodenal content.

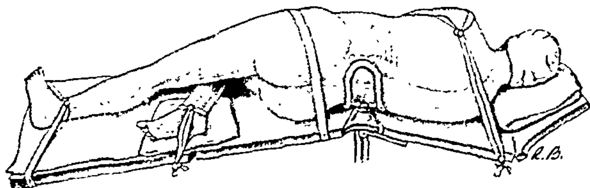


FIGURE 771 Method of fixing patient on operating table for kidney operation.

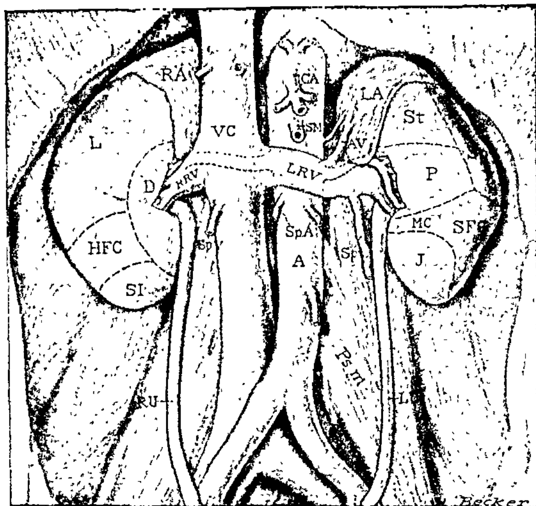


FIGURE 772. Anatomical relationships of the kidneys *A*, Aorta; *VC*, vena cava; *RA*, right adrenal; *LA*, left adrenal, *RRV*, right renal vein, *CA*, celiac artery, *SM*, superior mesenteric artery; *SpA*, spermatic arteries; *Spv*, spermatic veins, *LU*, left ureter, *RU*, right ureter; *PsM*, psoas muscle; *AV*, adrenal vein

Right Kidney *L*, Liver, *D*, duodenum; *HFC*, hepatic flexure of colon; *SI*, small intestines Left Kidney. *St*, Stomach; *Sp*, spleen; *P*, pancreas, *MC*, mesocolon, *SFC*, splenic flexure of colon and descending colon, *J*, jejunum (Goldstein Lewis' Practice of Surgery, W. F Prior Co)

Before attempting nephrectomy a careful study of all kidney anatomical relationships should be made (Fig. 772).

In some cases the extensive invasion of a tuberculous infection or a tumor may make nephrectomy too dangerous to undertake. In such instances attempts at removal of a kidney should be abandoned

Technique of Operation (Figs. 773 to 776)

An incision is made parallel to and about 2 cm below the twelfth rib, extending from the costovertebral angle downward for about 15 to 18 cm. to a point about 4 cm above the crest of the ilium. This incision is extended through the latissimus dorsi and oblique muscles and lumbodorsal fascia to expose the retroperitoneal fat. The costovertebral ligament is isolated and cut to permit increased mobility upward of the twelfth rib. Exposure can be improved by removing the twelfth rib or by dividing it and possibly the eleventh rib near their posterior attachments.

The perirenal fascia (Gerota's capsule) is incised and retracted to expose the perirenal fat. By careful blunt and sharp dissection the kidney is freed and delivered

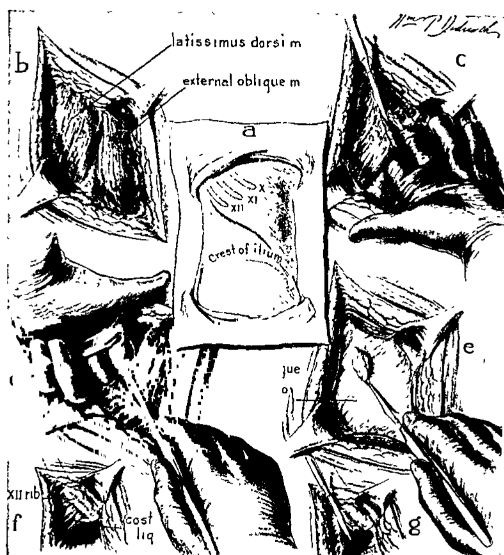


FIGURE 773. Extraperitoneal lumbar nephrectomy *a*, Skin incision; *b*, the latissimus dorsi and external oblique muscles are exposed, showing the triangle of Petit; *c*, the latissimus dorsi muscle is divided, *d*, the external and internal oblique muscles are divided, *e*, the lumbodorsalis fascia is incised to expose the retroperitoneal fat, *f*, *g*, the costovertebral ligament is exposed and divided. (Lowsley and Kirwin· Clinical Urology, Williams & Wilkins Company.)

into the wound. All bleeding vessels should be clamped and ligated as this dissection proceeds. The ureter is next isolated and retracted with a tape. If the kidney is removable, the ureter is clamped and divided between ligatures.

The *isolation and ligation of the kidney pedicle* is the most critical part of the operation. All tissues about the pedicle should be carefully divided. The fat and fascia over the pedicle can usually be pushed aside by sponge dissection. The pedicle may be ligated before or after the removal of the kidney, depending upon the technical difficulties involved. If the ligation is done before cutting away the kidney, two clamps are placed on the pedicle A ligature of no. 1 or 2 chromic catgut is tied about the pedicle as the proximal clamp is removed. A second ligature is placed distal to the first, and between them a transfixing ligature may be placed to add security. If the kidney is to be removed before the pedicle is ligated, three clamps are applied to the pedicle, and the pedicle is sectioned between the two distal clamps. As the proximal clamp on the pedicle is removed, a heavy chromic catgut ligature is placed in the groove made by the clamp A second ligature is then placed as the distal clamp is removed.

In rare instances ligature or suture of the pedicle may seem impossible; in such

cases the clamps may be left on the pedicle to protrude from the wound for several days until the pedicle has healed. This method of treatment should never be used when it can be avoided, and it usually can be avoided by careful exposure and extreme care in suture and ligation.

The wound is closed in layers with no. 0 chromic catgut. A Penrose type of drain is placed in the renal bed to emerge at the upper end by the incision.

In cases of extensive tuberculosis or tumor of the kidney involving the ureter, a *nephroureterectomy* should be done. The ureter can usually be removed with the kidney by extending the lumbar incision downward medial to the anterior superior spine of the ilium. In some cases a second incision at the margin of the rectus muscle may be desirable to increase exposure. The ureter is freed down to the bladder, divided and ligated. The lower end of the ureter may be invaginated with a purse-string suture, or the vesical portion may be excised, followed by closure of the bladder wall with sutures.

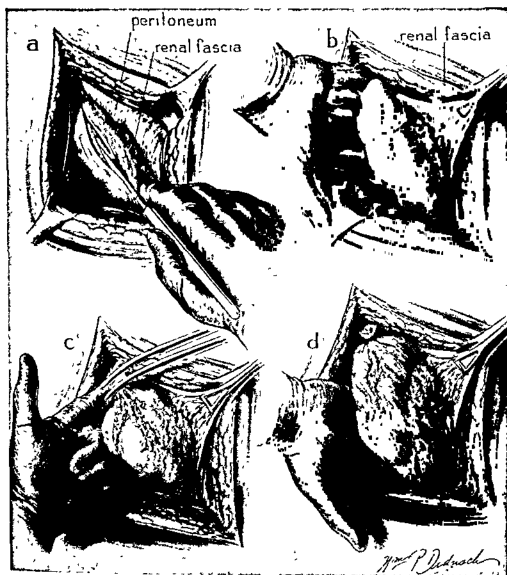


FIGURE 774 Extraperitoneal lumbar nephrectomy (*continued*). *a*, The perirenal fascia (Gerota's capsule) is incised; *b*, adipose tissue is separated from the kidney by sharp and blunt dissection; *c*, the upper pole of the kidney is freed by clamping adhesions Aberrant vessels may be encountered when freeing the poles of the kidney *d*, Freeing the lower pole of the kidney (Lowsley and Kirwin: Clinical Urology. Williams & Wilkins Company.)

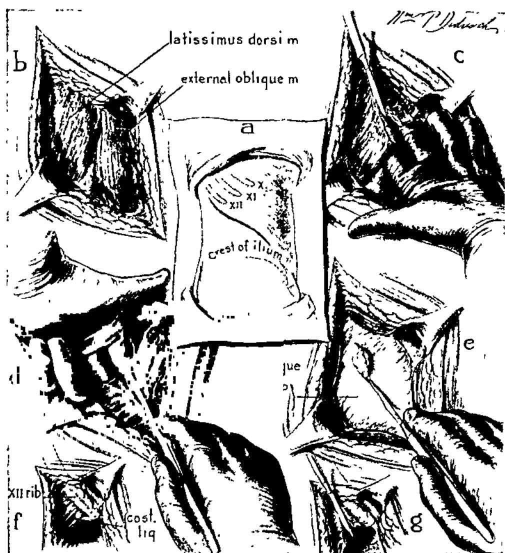


FIGURE 773. Extraperitoneal lumbar nephrectomy *a*, Skin incision; *b*, the latissimus dorsi and external oblique muscles are exposed, showing the triangle of Petit; *c*, the latissimus dorsi muscle is divided; *d*, the external and internal oblique muscles are divided; *e*, the lumbodorsalis fascia is incised to expose the retroperitoneal fat, *f*, *g*, the costovertebral ligament is exposed and divided. (Lowsley and Kirwin· Clinical Urology, Williams & Wilkins Company)

into the wound. All bleeding vessels should be clamped and ligated as this dissection proceeds. The ureter is next isolated and retracted with a tape. If the kidney is removable, the ureter is clamped and divided between ligatures.

The *isolation and ligation of the kidney pedicle* is the most critical part of the operation. All tissues about the pedicle should be carefully divided. The fat and fascia over the pedicle can usually be pushed aside by sponge dissection. The pedicle may be ligated before or after the removal of the kidney, depending upon the technical difficulties involved. If the ligation is done before cutting away the kidney, two clamps are placed on the pedicle. A ligature of no. 1 or 2 chromic catgut is tied about the pedicle as the proximal clamp is removed. A second ligature is placed distal to the first, and between them a transfixing ligature may be placed to add security. If the kidney is to be removed before the pedicle is ligated, three clamps are applied to the pedicle, and the pedicle is sectioned between the two distal clamps. As the proximal clamp on the pedicle is removed, a heavy chromic catgut ligature is placed in the groove made by the clamp A second ligature is then placed as the distal clamp is removed.

In rare instances ligature or suture of the pedicle may seem impossible; in such

cases the clamps may be left on the pedicle to protrude from the wound for several days until the pedicle has healed. This method of treatment should never be used when it can be avoided, and it usually can be avoided by careful exposure and extreme care in suture and ligation.

The wound is closed in layers with no. 0 chromic catgut. A Penrose type of drain is placed in the renal bed to emerge at the upper end by the incision.

In cases of extensive tuberculosis or tumor of the kidney involving the ureter, a *nephroureterectomy* should be done. The ureter can usually be removed with the kidney by extending the lumbar incision downward medial to the anterior superior spine of the ilium. In some cases a second incision at the margin of the rectus muscle may be desirable to increase exposure. The ureter is freed down to the bladder, divided and ligated. The lower end of the ureter may be invaginated with a purse-string suture, or the vesical portion may be excised, followed by closure of the bladder wall with sutures.

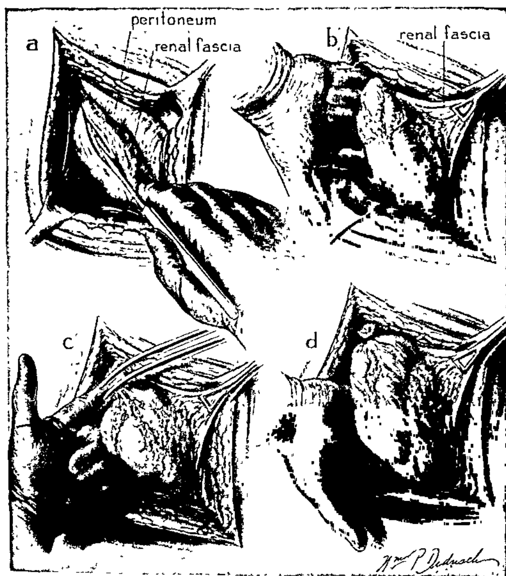


FIGURE 774 Extraperitoneal lumbar nephrectomy (*continued*). *a*, The perirenal fascia (Gerota's capsule) is incised; *b*, adipose tissue is separated from the kidney by sharp and blunt dissection; *c*, the upper pole of the kidney is freed by clamping adhesions. Aberrant vessels may be encountered when freeing the poles of the kidney. *d*, Freeing the lower pole of the kidney (Lowsley and Kirwin: Clinical Urology. Williams & Wilkins Company)

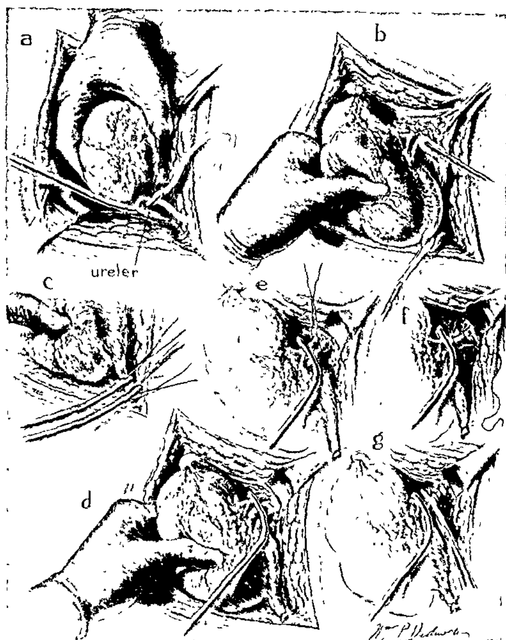


FIGURE 775 Extraperitoneal lumbar nephrectomy (*continued*). *a*, The freed kidney is liftec the wound, and a tape is passed beneath the ureter for traction *b*, The perirenal fat is dissected the vascular kidney pedicle. *c*, The ureter is divided between clamps and ligated. *d*, The first cla applied to the vascular pedicle *e*, The second clamp is applied to the pedicle, and the first cla removed. A ligature is being placed around the portion of the pedicle crushed by the first clar Two ligatures have been tied around the renal pedicle, and a transfixion suture is being placed. *h* pedicle is being divided distal to the 2 ligatures (Lowsley and Kirwin: Clinical Urology, Wil & Wilkins Company)

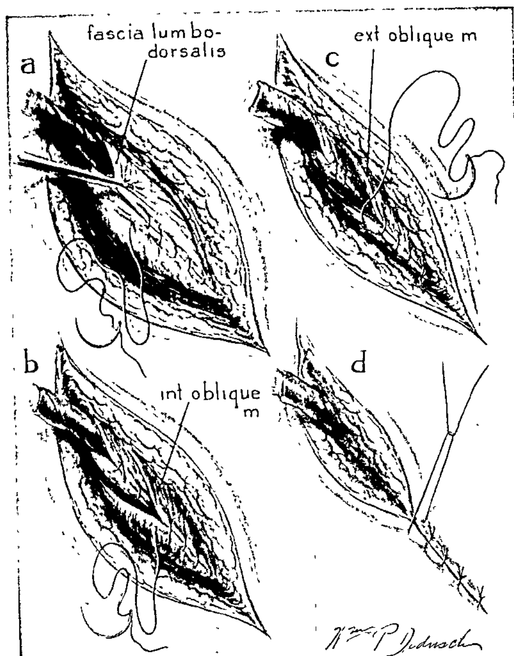


FIGURE 776 Extraperitoneal lumbar nephrectomy (*concluded*) *a*, Suturing the lumbodorsalis fascia, drain in place. *b*, *c*, Suturing the internal and external oblique muscles. *d*, Interrupted sutures in the skin (Lowsley and Kirwin Clinical Urology, Williams and Wilkins Company)

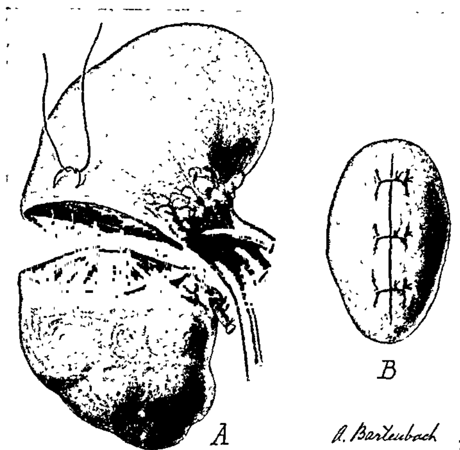


FIGURE 777. Resection of pole of kidney. *A*, A V-shaped incision is made through the kidney. Wound is closed with deeply placed mattress sutures *B*, Wound closure reinforced with interrupted sutures passed around the ends of the mattress sutures.

RESECTION OF THE KIDNEY

Indications

Resection of the kidney is indicated for certain types of solitary cysts, when one pole is destroyed by stones, or for localized pyogenic infection.

Technique of Operation (Fig. 777)

The kidney is completely freed as for nephrectomy. Any vessels supplying the pole to be resected are ligated and divided. To control hemorrhage during resection. Young has suggested constricting the renal pedicle with a rubber band.

A V-shaped incision is made into the kidney substance at the junction of the diseased and normal kidney tissue. This type of wound permits relatively easy approximation of the wound margins with deep mattress sutures of catgut. The capsule is closed with interrupted sutures. Drainage of the wound is imperative.

HEMINEPHRECTOMY FOR HORSESHOE KIDNEY

When half of a horseshoe kidney is diseased, it may be removed by heminephrectomy. Indications for this operation are not unlike those for removal of the normally located kidney.

Operations upon a horseshoe kidney are usually done by the transperitoneal

route. Since the anatomical structures are never the same in two cases, much technical care is necessary to avoid serious operative complications. Good results may be expected if the remaining half of the kidney is not diseased.

OPERATIONS UPON THE ECTOPIC KIDNEY

If an ectopic kidney is functioning and there are no signs or symptoms of disease, operative treatment is not indicated. Indication for treatment of the ectopic kidney is much the same as for a diseased kidney in its normal position. Nephropexy may occasionally be the treatment of choice for a movable ectopic kidney which is not diseased.

NEPHROPEXY

Indications

Suspension of the kidney to afford better drainage is indicated in selected cases of movable kidney and as a part of other operative procedures upon the kidney and ureter when fixation will improve function or prevent complications.

Technique of Operation (Cabot) (Figs. 778, 779, 780)

Nephropexy is done through the same type of incision used for nephrectomy. The costovertebral ligament is divided to improve exposure. To free the kidney for

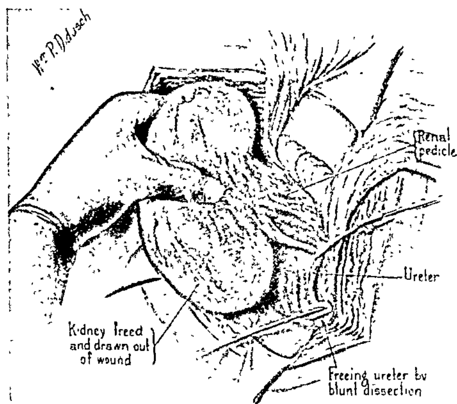


FIGURE 778 Cabot's technique of nephropexy The kidney, kidney pedicle and upper portion of the ureter are completely exposed All adhesions are cut, and any aberrant vessels are divided and ligated Adequate exposure permits correction of strictures, and angulations of the ureter or operation upon the kidney pelvis preparatory to suspension of the kidney (Cabot: Modern Urology, Lea & Febiger.)

suspension, it is necessary to separate it completely from its fatty capsule. Adhesions about the kidney or kidney pedicle will prevent proper suspension and fixation. The ureter is also freed well below the kidney pelvis. Adhesions and aberrant vessels about the ureter must be removed to relieve angulation or obstruction.

The capsule of the kidney is split along its external border and stripped from the kidney surface to form capsular flaps. The capsule of the lower pole is left intact. Four sutures are placed in the capsular flap. The upper two sutures are passed through the intercostal muscle above the twelfth rib and tied. This procedure draws the upper pole of the kidney above the level of the eleventh rib. Injury to the pleura is avoided by passing the needles near the twelfth rib. The lower portion of the capsular flaps is fixed to the abdominal fascia and quadratus lumborum muscles by the two lower sutures. *To aid in the support of the kidney, the perirenal fatty capsule is sutured over* the lower portion of the kidney to the quadratus lumborum muscle.

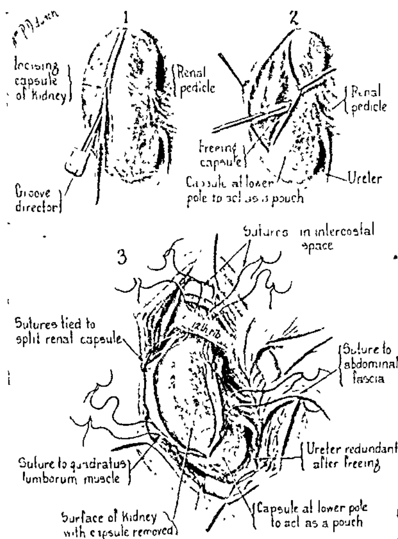


FIGURE 779 Cabot's technique of nephropexy (*continued*) *1* and *2*, The kidney capsule is incised over a groove dissector, and the capsule is stripped up to form flaps The capsule of the lower pole is left intact as a suspensory pouch. *3*, Four sutures are placed in the capsular flaps The 2 upper sutures are passed beneath the twelfth rib and through the intercostal muscle. When tied, these upper sutures will bring the upper pole of the kidney above the level of the eleventh rib (Cabot. Modern Urology, Lea & Febiger)

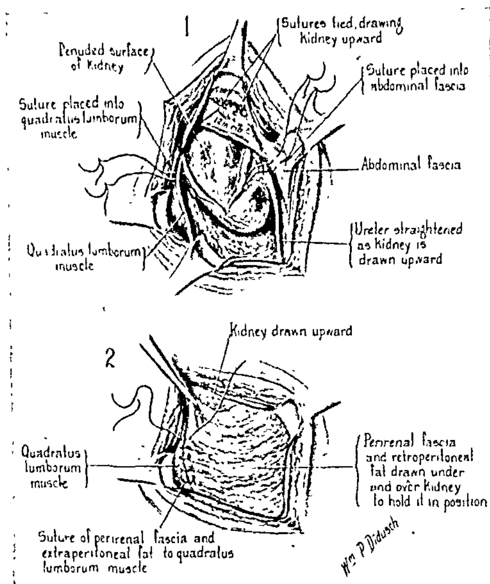


FIGURE 780. Cabot's technique of nephropexy (*concluded*) *1*, The 2 sutures passed above the twelfth rib have been tied. The 2 lower sutures are fixed to the quadratus lumborum muscle and abdominal fascia. When the kidney is suspended, the ureter is straightened *2*, The perirenal fascia and fatty capsule are brought across the lower pole of the kidney and sutured to the quadratus lumborum muscle. This cushion of fat and fascia creates new adhesions and aids in maintaining the kidney in its suspended position (Cabot· Modern Urology, Lea & Febiger)

The wound is closed in layers with interrupted no 0 chromic catgut sutures in the muscle and fascia and silk in the skin. Drainage is usually not necessary.

OPERATIONS FOR HYDRONEPHROSIS

General Considerations

Operations for hydronephrosis are designed to relieve obstruction in the urinary tract and improve kidney drainage. When the kidney is damaged beyond repair by pressure or infection, nephrectomy is indicated. If the hydronephrosis is bilateral, or if the uninvolved kidney is diseased, nephrectomy is contraindicated. When possible, the kidney should be preserved by operative measures designed to relieve strictures

and to remove stones or other causes of obstruction. Plastic operations upon the ureter or kidney pelvis, or both these structures, are frequently advisable.

Technique of Operation for Obstruction at the Ureteropelvic Junction (Fig. 781)

Obstruction at the ureteropelvic junction due to aberrant vessels, adhesions and movable kidney may be relieved by division of adhesions, section and ligation of vessels, and nephropexy. Short strictures of the ureter may be corrected by one of the several methods described below.

A longitudinal incision through the stricture and closure of the wound transversely may be sufficient to restore the ureteral lumen (Heineke-Mikulicz).

A Y-shaped incision at the ureteropelvic junction followed by a V-shaped closure of the wound will, in selected cases, cure a stricture (Foley).

A plastic operation upon the kidney pelvis and ureter, using the principle of the Finney pyloroplasty, will eliminate constriction.

A plastic operation may be used to reduce the size of the distended kidney pelvis. Portions of the anterior and posterior walls of the pelvis are resected (Young).

When there is marked angulation and constriction of the ureter at the ureteropelvic junction, the ureter may be divided, ligated, and implanted into the lower portion of the kidney pelvis. The ureter may be divided obliquely and sutured directly into an opening in the pelvis, or it may be split and the ends sutured to the pelvic wall a short distance inside the opening.

Plastic operations upon the ureter and kidney pelvis at the ureteropelvic junction should usually be accompanied by nephrostomy or pyelostomy. In some cases nephropexy will obviate the necessity of draining the kidney pelvis. A ureteral catheter introduced through a cystoscope will splint the ureter during the healing period.

NEPHROTOMY AND NEPHROSTOMY

Indications

Incision into the kidney, with or without drainage, is most frequently indicated for the removal of stones. Indications for nephrostomy are drainage following plastic operations upon the ureteropelvic junction, failing renal function due to obstruction of the ureters caused by calculus, tuberculosis or malignant disease.

A stone in the kidney that cannot be easily removed by pyelotomy should be removed through an incision into the kidney, except in those cases of kidney stone with great destruction of kidney tissue, when nephrectomy is the operation of choice.

Technique of Operation for Kidney Stone (Fig. 782)

Through a lumbar incision the kidney is freed and carefully palpated to locate the stone When the stone is near the cortex of the kidney, a short incision may be made and spread with a hemostat until the stone can be extracted. If the stone is large or of the staghorn type, an incision should be made into the kidney along Brödel's line, which is just posterior to the convex border (Fig. 783). With this incision a minimum of bleeding is encountered. Bleeding may be controlled in some measure by digital compression of the kidney pedicle. The stone is carefully extracted to avoid

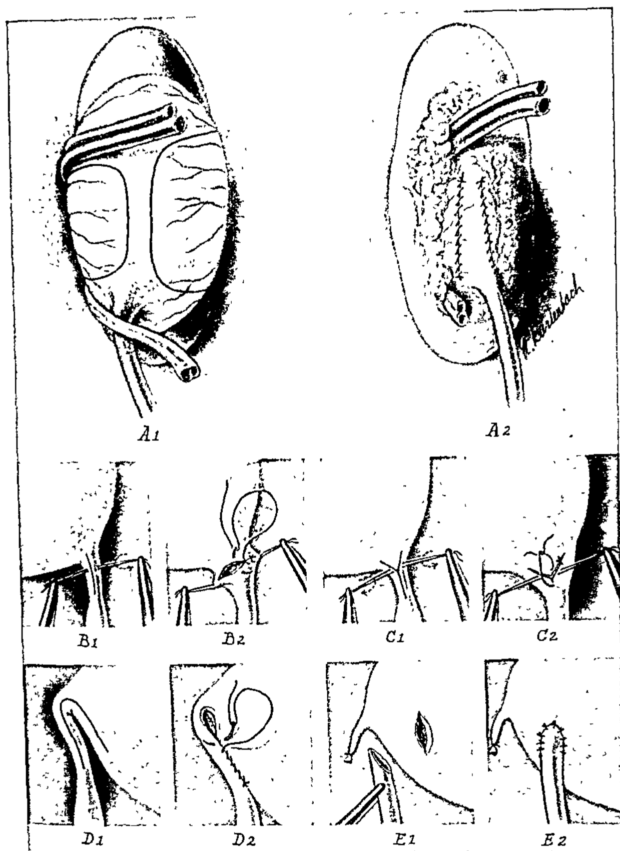


FIGURE 781. Plastic operations for hydronephrosis. A_1 and A_2, Resection of kidney pelvis. Aberrant vessels have been removed (Redrawn from Young) B_1 and B_2, Mikulicz type of operation C_1 and C_2, Foley Y-shaped incision D_1 and D_2, Young's ureteropyeloplasty. E_1 and E_2, Young's method of implanting ureter into kidney pelvis

FIGURE 782. Nephrotomy for kidney stone Kidney incised along Brodel's line, exposing stones

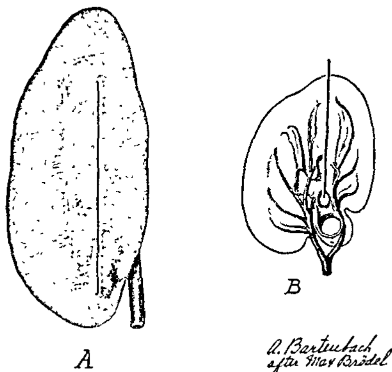


FIGURE 783. Brodel's line. *A*, Line just posterior to the convex border of the kidney locates the plane of least vascularity *B*, Cross section of kidney, showing safe plane for incision (Redrawn from Kelly and Burnam)

unnecessary trauma to the kidney parenchyma. Septa may be present which require division. Stones may be multiple or may break during removal.

All parts of the kidney must be explored by palpation and probing to avoid leaving a stone behind. The stone removed should be compared to that seen in the x-ray film. When possible, the kidney should be examined with a fluoroscope or by roentgenography before the operation is finished.

The kidney is closed with mattress sutures of chromic catgut, reinforced with interrupted sutures in the cortex. When drainage is necessary, a small rubber tube or catheter with two or three side openings should be passed into the kidney pelvis before closing the wound. The drainage tube should not be passed far enough to impinge upon the ureteropelvic orifice.

The lumbar incision is closed in layers as in nephrectomy, leaving room for the nephrostomy tube and a Penrose drain to emerge at the upper end of the incision.

Technique of Nephrostomy

When nephrostomy is done for kidney drainage alone, the technique of Cabot is satisfactory. Through an opening made in the kidney pelvis, a bent uterine sound is passed out through the kidney substance. To this sound is tied a heavy silk ligature which is withdrawn through the kidney pelvis. A catheter is then tied to the ligature and drawn through the tract made by the sound in the kidney substance. Temporary or permanent kidney drainage can be obtained by this method.

PYELOTOMY AND PYELOSTOMY

Indications

Pyelotomy and pyelostomy are most frequently indicated for the removal of stones from the kidney pelvis or calices. Drainage of the kidney pelvis may also be indicated after a plastic operation upon the kidney pelvis or ureteroplevic junction.

Technique of Operation for Kidney Stone (Fig. 784)

The kidney is exposed as in nephrectomy. To expose the kidney pelvis, it is necessary to free the kidney so that it may be lifted into the wound. All fat and fascia are removed from the kidney pelvis and first portion of the ureter. An incision is made into the kidney pelvis of sufficient length to extract the stone and explore the pelvis and calices This incision should not encroach upon the kidney pedicle or the ureteral orifice. After extracting the stone or stones, a careful search should be made by palpation and instrumentation to avoid leaving stones or gravel behind. Irrigation and suction may be used to wash out the kidney pelvis and calices. A fluoroscopic examination or an x-ray film should be made to assure complete removal of all stones.

If there is no infection and the ureter is normal, the pelvic wound may be closed without drainage If there is much infection, damage to kidney tissue or poor ureteral drainage, a pyelostomy is indicated. For drainage, a catheter or small rubber tube is inserted into the pelvis and fixed with a catgut suture.

The rubber tube and a Penrose type of drain are placed in the upper end of the incision, which is closed in layers.



FIGURE 784. Pyelotomy for removal of stone from the kidney pelvis. *a*, Blunt gauze dissection is used to expose the pelvis. *b*, The ureter is lifted with a tape, and an incision is being made over a stone in the pelvis *c*, The wound in the pelvis has been closed with fine chromic catgut *d*, The incision has been closed transversely to widen the pelvis This is not usually necessary unless there is some angulation or constriction at the ureteropelvic junction (Young Practice of Urology.)

DRAINAGE OF PERINEPHRITIC ABSCESS

Technique of Operation

An incision is made 7 to 8 cm. in length about 3 cm. below and parallel with the twelfth rib. This incision is deepened through the muscle and fascia down to the fatty capsule. The perirenal fat is involved, and the induration caused by the abscess can usually be felt with the examining finger. A hemostat is used to locate and open the abscess. Digital exploration is advised to determine the extent of the abscess cavity and to open any accessory pockets. Care should be taken not to spread infection by breaking down the main protecting wall of the abscess. Drainage is always necessary.

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CHAPTER 20

Female Reproductive System

OPERATIONS UPON THE VAGINA

EXCISION OF BARTHOLIN GLAND CYST

Indications

Infection of a Bartholin gland is usually due to gonorrhea. Such an infection may develop into an acute abscess or become chronic with cyst formation. An acute abscess of a Bartholin gland will frequently rupture spontaneously. Excision of a chronically infected cyst should be done during a quiescent period.

Technique of Operation (Fig. 785)

An incision is made over the most prominent part of the cyst. Dissection about the cyst is somewhat difficult, and bleeding may be troublesome. Removal may be simplified by opening the cyst and grasping its posterior wall with an Allis clamp to produce traction as the cyst wall is peeled out by blunt dissection. The base of the cyst is sutured or ligated to control bleeding. Rows of fine catgut sutures are used to close the wound and to control bleeding Drainage is usually not necessary.

REMOVAL OF URETHRAL CARUNCLE

Indications

A urethral caruncle is a small, red tumor-like growth usually located within the posterior wall of the meatus. A caruncle that does not produce symptoms rarely requires treatment. If there is pain or bleeding, removal is indicated. Recurrence is common if the base of the tumor is not removed.

Technique of Operation

The caruncle with its base may be completely excised. Sutures of fine catgut used to close the wound should not constrict the meatus.

Fulguration is usually the procedure of choice. Te Linde prefers to clip off the caruncle for microscopic examination and then fulgurate the base thoroughly.

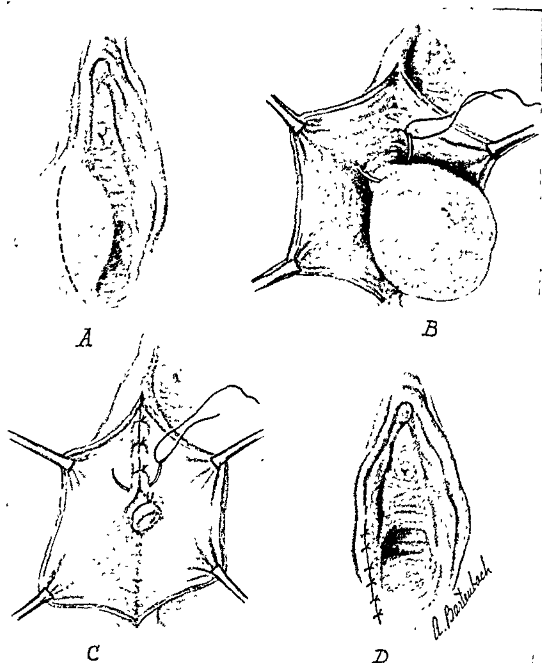


FIGURE 785. Excision of Bartholin cyst. *A*, Line of incision *B*, Cyst dissected free ready for pedicle ligation *C*, Sutures to obliterate cavity *D*, Skin closed with interrupted sutures

PERINEORRHAPHY FOR PERINEAL RELAXATION AND RECTOCELE

Indications

Injuries of perineal tissues are usually due to both tearing and stretching of the vaginal outlet during childbirth. Minor lacerations of the perineum rarely require surgical treatment. When symptoms are produced by the general relaxation of the pelvic floor with its associated rectocele and cystocele, operative repair is generally indicated. Perineorrhaphy is contraindicated in patients of advanced years who are relatively inactive, women who desire more children, and the physically infirm.

Dangers and Safeguards

The object of perineal repair is to *restore* the pelvic floor as a supporting structure. When the indications are definite, the results should be satisfactory.

Infection is a complication which may occur, causing a breakdown of the tissues along the suture line. This complication can be reduced to a minimum by careful preoperative local preparation, by closure of the tissues without tension, and by careful hemostasis. As a part of the postoperative care, cleansing of the suture line after each urination and bowel movement will reduce the incidence of infection. Preoperative and postoperative antibiotic therapy with a broad-spectrum drug also helps reduce the incidence.

When the operation is completed, the vaginal orifice should be normal in size. Constriction of the vaginal canal may result from a too snug closure of the levator muscles and perineal fascia. The sutured tissues of the perineum do not tend to relax, and a small vaginal outlet may cause a tender scar and dyspareunia.

Technique of Operation (*Figs. 786 to 789*)

Allis clamps are applied in the midline posteriorly, at the mucocutaneous line on each side of the vaginal outlet at the lower border of the hymen, and at a midline point in the posterior vaginal wall just above the rectocele. These clamps are used for markers and for traction during the dissection of the vaginal floor.

An incision is made along the margin of the vaginal orifice between the lateral clamps. From this incision the posterior vaginal wall is separated from the rectal wall

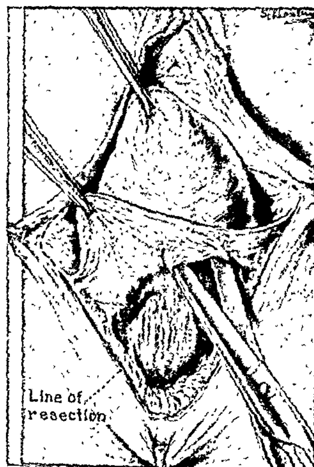


FIGURE 786. Repair of relaxed perineum and rectocele Allis clamps are applied for traction, and vaginal wall is separated from rectum with sharp and blunt dissection The dotted line outlines the area to be denuded (Richardson. Am J Obst. & Gynec , Vol. 34)

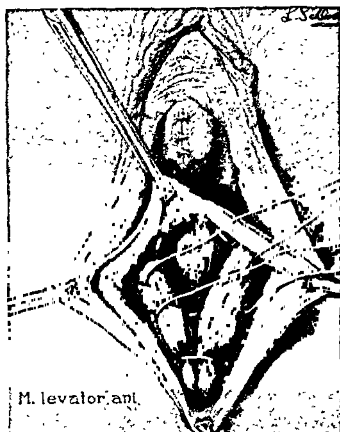


FIGURE 787. Repair of relaxed perineum and rectocele (*continued*) The redundant vaginal wall has been dissected free and removed. The levator muscles and fascia are being united with interrupted chromic catgut sutures in front of rectum The upper suture grasps the under surface of vaginal wall. Drawing also shows suture line of cystocele repair. (Richardson: Am. J. Obst. & Gynec., Vol. 34.)

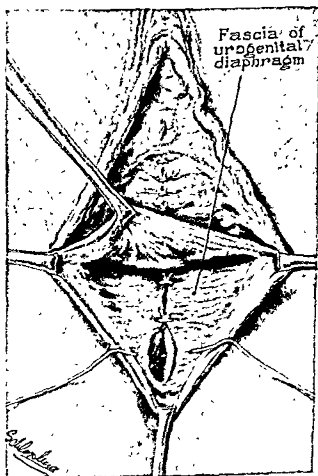


FIGURE 788. Repair of relaxed perineum and rectocele (*continued*) The fascia of the urogenital diaphragm is sutured over the levator muscles and fascia Suture line of cystocele operation shown in drawing. (Wharton Gynecology.)

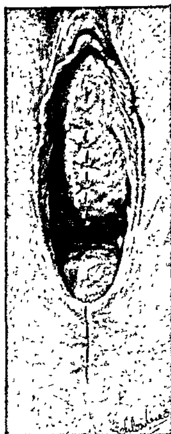


FIGURE 789. Repair of relaxed perineum and cystocele (*concluded*). Repair of perineum completed. Skin has been closed with subcutaneous sutures. Sutures of cystocele repair shown in anterior vaginal wall. The vaginal orifice is normal in size (Richardson: Am. J. Obst. & Gynec., Vol. 34.)

up to the upper margin of the rectocele. This dissection forms an inverted V-shaped denudation of the vaginal mucosa. The V-shaped flap of vaginal mucosa is cut away. The levator ani muscles and fascia are united with interrupted chromic catgut sutures. The upper suture is passed through the tissue beneath the vaginal mucosa to form the crown suture of Emmet. Over the sutured levator ani muscles and fascia the urogenital diaphragm of fascia is closed with interrupted chromic catgut sutures. The vaginal wall defect and skin are closed with interrupted sutures of fine chromic catgut. A subcuticular suture of plain catgut may be used for the skin, if desired, as shown in the illustration.

PERINEORRHAPHY FOR COMPLETE PERINEAL TEAR

Indications

Complete perineal tears involving the rectum should be repaired when they occur. As soon as delivery is complete, the tissues of the perineum should be sutured with chromic catgut, beginning with the tear in the sphincter muscle and rectum.

Old complete tears produce anal incontinence and should be repaired by carefully executed plastic operations. Wharton states that satisfactory operative results may be obtained in almost 90 per cent of such operations.

Technique of Operation (Figs. 790 to 795)

If the tear extends into the rectum, an inverted V-shaped incision is made in the vaginal wall to permit the construction of a vaginal flap. This flap is retracted over

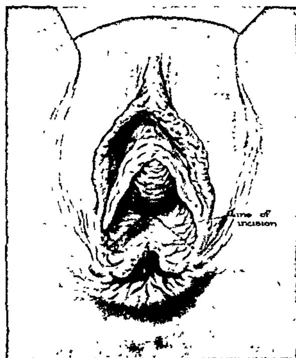


FIGURE 790. Repair of complete perineal tear. Line of incision used for the construction of a vaginal flap (Miller and Brown: Am. J. Obst. & Gynec., Vol. 34.)

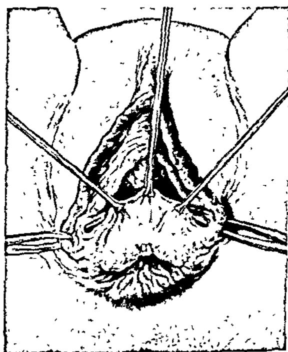


FIGURE 791. Repair of complete perineal tear (*continued*) The vaginal flap has been *mobilized. By retracting flap over anus, it* serves as a protection against contamination. (Miller and Brown: Am. J. Obst. & Gynec., Vol 34.)

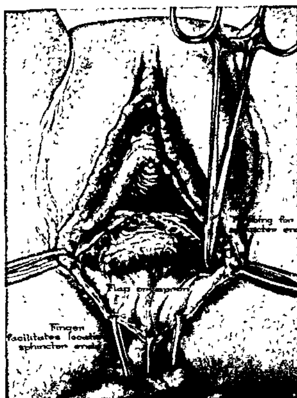


FIGURE 792. Repair of complete perineal tear (*continued*). The ends of the sphincter ani muscles are located chiefly by blunt dissection. (Miller and Brown: Am. J. Obst. & Gynec., Vol. 34.)



FIGURE 793 Repair of complete perineal tear (*continued*). The ends of the sphincter muscle have been dissected free. Some fascia should be included with the sphincter ends so that they will better hold sutures Too much separation of the muscle ends may damage the blood supply and innervation (Miller and Brown: Am. J. Obst. & Gynec., Vol 34.)

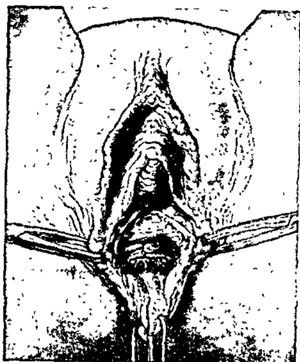


FIGURE 794. Repair of complete perineal tear (*continued*). The ends of the sphincter muscle have been overlapped and united with mattress sutures of fine chromic catgut. The next step, not shown here, is suture of the circumanal fascia. Suture of this fascia adds support to the sphincter and levator ani muscles. (Miller and Brown: Am. J. Obst. & Gynec, Vol. 34.)

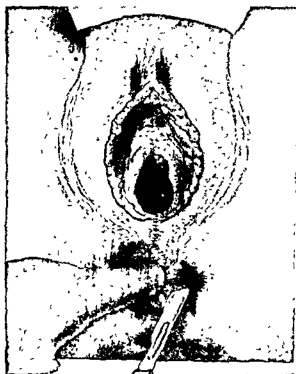


FIGURE 795. Repair of complete perineal tear (*concluded*). The vaginal wall has been sutured, utilizing the vaginal flap to reconstruct the rectal and anal walls. If tension is great, the external sphincter muscle may be cut in the posterior quadrant as shown. (Miller and Brown Am J Obst & Gynec., Vol. 34.)

the anus during the plastic repair and forms a barrier against contamination of the operative field.

The scarred ends of the external sphincter muscle are located by blunt and sharp dissection The ends of the muscles are mobilized, overlapped, and united with mattress sutures of fine chromic catgut. To support the sphincter muscle, the anal fascia is next sutured.

If there is a rectocele, it should be corrected by suturing the levator ani muscles and fascia of the urogenital diaphragm. The vaginal wound is closed so that the V-shaped vaginal flap may be utilized to reconstruct the rectal and anal walls.

When operation involves the rectal wall, requiring extensive plastic repair, postoperative rest of the tissues for at least a week is important. After seven or eight days mineral oil and oil retention enemas are given to move the bowels. A saline cathartic may be necessary in some cases. When the rectum is not involved in the tear, the bowels may be moved in two or three days.

REPAIR OF CYSTOCELE AND URETHROCELE

General Considerations

Operation is *indicated* for a cystocele which produces symptoms, Urethrocele is frequently associated with cystocele, and the two are repaired by the same operation. Incontinence of urine, caused by coughing, sneezing or straining, may be a part of the symptom complex produced by cystocele, urethrocele, and relaxation of the vesical sphincter. The incontinence can usually be corrected by plicating the tissues around the posterior urethra and vesical sphincter over a urethral catheter.

When cystocele is associated with a retrodisplacement of the uterus, an abdominal suspension of the uterus may be a necessary part of the operative repair. Likewise an associated prolapse of the uterus, in women advanced in years, is frequently an indication for the Watkins-Wertheim interposition operation or a vaginal hysterectomy with cystocele repair. A perineal repair is made as a part of the operation for cystocele or uterine prolapse.

Dangers and Safeguards

Wounding of the bladder or urethra is probably the most important error to be avoided when repairing a cystocele. Such a wound might be unrecognized during the operation and result in later development of a fistula. Too much infolding of the base of the bladder may impinge upon the ureteral orifices and produce partial obstruction of the ureters.

The dissection must be carefully done and be extensive enough to effect a cure. The beginner or the inexperienced surgeon is prone to do an incomplete operation.

Hemostasis is important to prevent the formation of postoperative hematomas which prevent smooth wound healing.

If the patient's sexual life is to continue, care must be used not to excise too much of the vaginal wall. This precaution is also necessary in the perineal repair. Too much tension placed upon the deeper tissues of the perineum may result in a permanently painful condition.

Retention of urine is usual after operation. This may be treated with an indwelling catheter and bladder irrigations or by repeated catheterization at regular intervals. If retention is prolonged, Curtis advises "distention treatment" of the bladder. The bladder is distended daily with sterile water. This aids in ironing out folds and creases in the bladder. The distention should not be great enough to produce severe pain.

There may be *residual urine and infection* after the patient has begun to void. If this occurs, the bladder should be emptied with a catheter and irrigated with boric acid

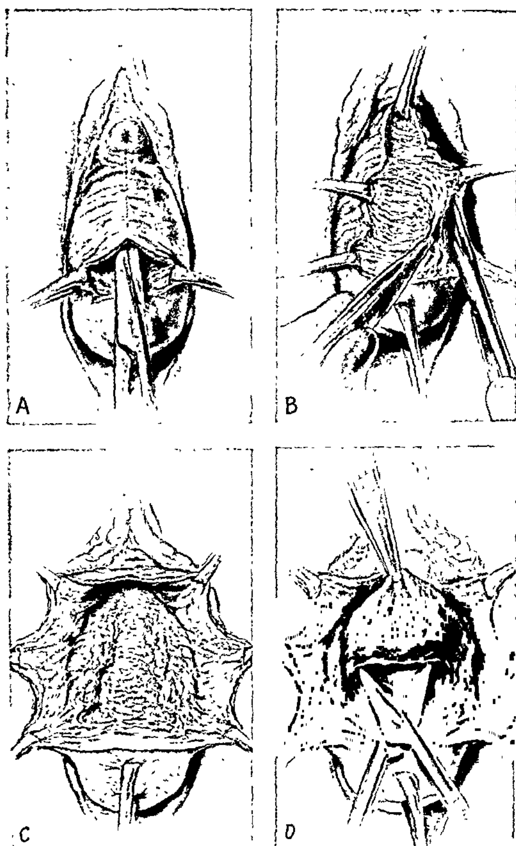


FIGURE 796 Advancement operation for cystocele *A*, Through a short transverse incision a pathway is made between the vaginal wall and bladder with scissors. *B*, Vaginal wall is raised lateralward on each side a distance of several centimeters and separated from the underlying musculofascial tissue *C*, When patients have incontinence, this dissection must be made with care and thoroughness about the urethra. *D*, The bladder is separated from the cervix by dissecting close to the cervix. (Curtis. Textbook of Gynecology)

solution until the infection is cured and function of the bladder returns. Such infections will usually be controlled by sulfisoxazole or another antibiotic to which the offending organisms are sensitive.

Technique of Operation (Figs. 796, 797, 798)

The cervix is drawn downward to the vaginal outlet with a tenaculum. Beginning at the junction of the cervix and the anterior vaginal wall, a short transverse incision is made. With blunt scissor dissection the vaginal wall is separated from the bladder along the musculofascial plane. The vaginal wall is then incised in the midline to a point just posterior to the urethral meatus. Vaginal flaps are dissected up to the lateral walls of the vagina. If there is incontinence of urine, the vaginal flaps are dissected forward to the meatus on each side of the urethra. The bladder is separated from the cervix by careful blunt and sharp dissection and pushed upward.

The urogenital diaphragm is united below the urethra to correct the urethrocele and incontinence. A catheter in the urethra may be used as a guide.

The first suture placed to correct the cystocele passes inward through the musculofascial tissue on one side, and, as the bladder is held upward, grasps the wall of the uterus above the level of the internal os, and finally passes outward through the musculofascial tissue on the opposite side. Similar sutures are placed at lower levels to approximate the musculofascial layers. Finally the vaginal flaps are trimmed to fit and closed in the midline.

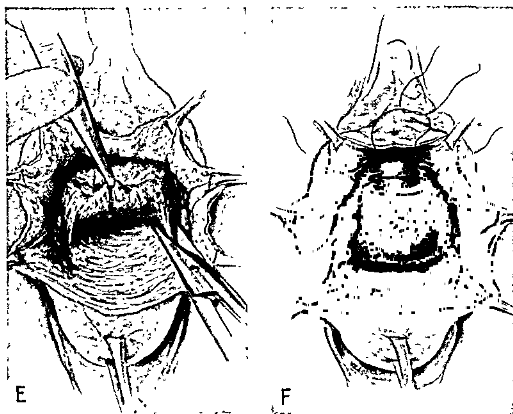


FIGURE 797. Advancement operation for cystocele (*continued*) *E*, The pillars are cut, and the bladder is pushed upward *F*, Mattress sutures are used to close the tissue of the urogenital diaphragm beneath the urethra. (Curtis Textbook of Gynecology.)

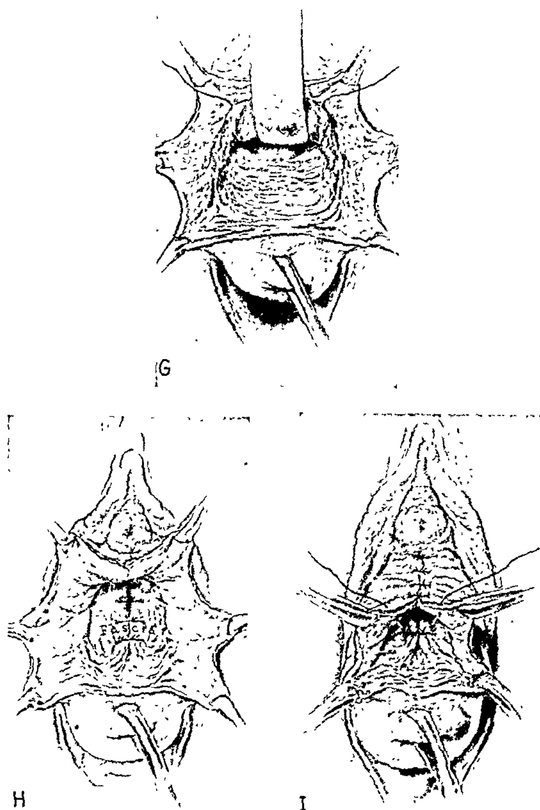


FIGURE 798 Advancement operation for cystocele (*concluded*) *G*, As the bladder is held up with a retractor, a deep suture is taken through the lateral musculofascial tissue and through the wall of the uterus above the level of the internal os *H*, Additional sutures close the firm musculofascial tissue to correct the herniation of the bladder *I*, The vaginal flaps are trimmed and approximated with interrupted chromic catgut sutures. These sutures grasp the underlying musculofascia The relaxed perineum is repaired as a routine (Curtis Textbook of Gynecology)

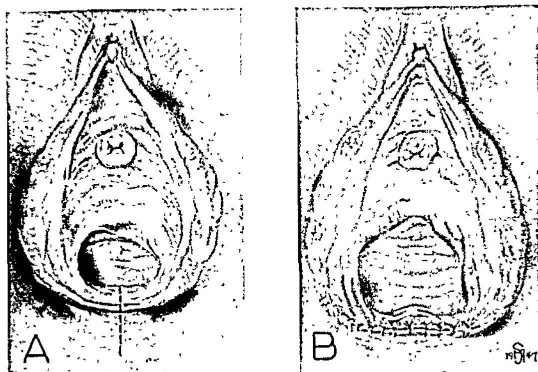


FIGURE 799. Technique of enlarging vaginal outlet. *A*, Line of incision in vaginal wall and skin. *B*, Incision closed transversely with interrupted sutures.

OPERATION FOR ENLARGING VAGINAL OUTLET

Technique of Operation (Fig. 799)

A longitudinal incision is made in the midline, extending from 1 cm. within the vagina downward through the perineal skin a distance of 1 cm. The subcutaneous scarred tissue is incised. The flaps are undercut a distance of about 1 cm., and the wound is closed transversely with interrupted sutures of catgut. In order to make a smooth closure of the incision, it may be necessary to cut away some of the superficial scar tissue beneath the flaps.

IMPERFORATE HYMEN

Technique of Excision of Imperforate Hymen (Fig. 800)

A crucial incision is made through the hymen. The four quadrants of the hymen are then excised to the wall of the vagina. To control bleeding, the wound about the vaginal outlet is then closed with interrupted sutures of no. 000 plain catgut.

DRAINAGE OF PELVIC ABSCESS (POSTERIOR COLPOTOMY)

Indications

Collections of pus deep in the cul-de-sac may be drained through the posterior vaginal wall. Patients must be selected carefully to avoid injury to the rectum or small intestine. Too vigorous or too extensive procedures may cause general peritonitis or an increase in the pelvic cellulitis.

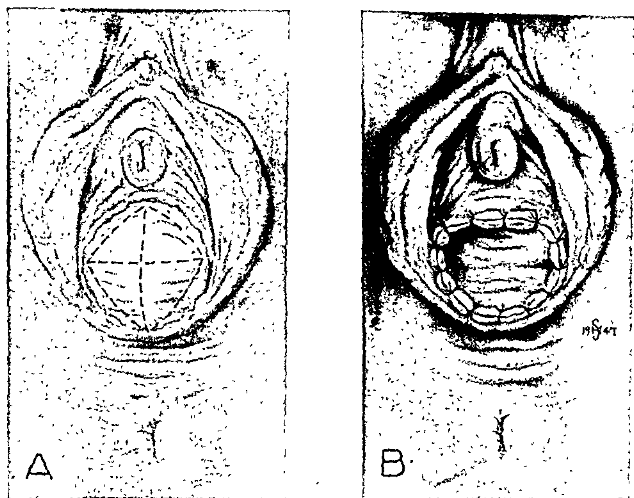


FIGURE 800. Technique of excision of imperforate hymen. *A*, Lines of incision to excise hymen. *B*, Interrupted sutures closing wound in vaginal wall

Fluctuation should be evident behind the cervix before operation is attempted. In some cases the presence of fluctuation and the decision to drain through the posterior vaginal wall must be determined after examination, with the patient anesthetized. Both rectal and vaginal examinations should be made to outline the abscess before drainage is attempted.

Technique of Operation (Fig. 801)

Good exposure of the vaginal vault is essential. Blind surgery should never be attempted.

A transverse incision 3 to 5 cm. long is made in the posterior vaginal wall at or near its junction with the posterior surface of the cervix. The tissues posterior to the uterus are then carefully divided by blunt and sharp dissection. Crossen emphasized the point that the direction of the dissection should be carried between the uterus and the abscess rather than between the rectum and the abscess. This can be readily done by following the rigid posterior wall of the cervix by palpation as the operation proceeds. In long-standing abscesses there may be a thick indurated abscess wall that will require sharp dissection to penetrate. It should be kept in mind that a retrodisplaced fundus of the uterus or a large fecal mass in the rectum may be mistaken for an abscess.

After the abscess wall has been punctured the opening is widened with scissors.

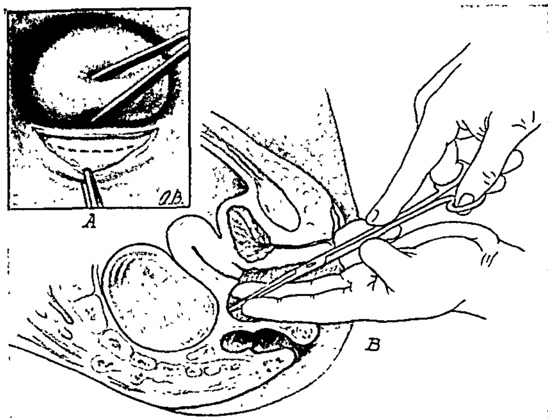


FIGURE 801. Drainage of pelvic abscess. *A*, Line of incision in posterior vaginal wall near cervix. *B*, Method of introducing scissors into abscess.

Gentle digital examination of the interior of the abscess is indicated to unite pockets of a multilocular abscess. The protecting wall of the abscess must not be penetrated.

The abscess cavity should be drained with at least two Penrose or cigarette drains. Rubber tube drainage is contraindicated because of the danger of pressure erosion into the rectum or small bowel. Irrigations of the cavity are not advised, since they add little to the effectiveness of the drainage and might cause a break in the abscess wall resulting in peritonitis. Drains can usually be safely removed in eight to ten days.

REPAIR OF VESICOVAGINAL FISTULA

General Considerations

Vesicovaginal fistulas caused by childbirth, trauma or infection can usually be repaired. Large fistulous openings, due to extensive sloughing of the vesical wall or destruction by malignant tumors, are incurable by local operation. In such cases relief can be obtained by implantation of the ureters into the rectum or, preferably, by construction of an ileal bladder.

Dangers and Safeguards

It is a well known fact that many vesicovaginal fistulas are difficult to close. Repeated attempts are not infrequently necessary before operation is successful. Difficulties may be reduced to a minimum by a careful study of the condition before operation and by *proper timing of the operation.* Closure of a fistula should not be planned

until the tissues surrounding the fistula are healed and free from infection and edema. An exception to this rule may be made in fresh wounds, which may be closed at once. If a primary operation fails, four to six months should elapse before another operation is attempted.

The importance of *scrupulous care* in separation and closure of tissue layers is emphasized. Simple suture of a fistulous tract is rarely successful. Occasionally a small fistula may be closed by cauterization and bladder drainage.

Careful postoperative treatment is essential to success. An indwelling catheter should be used for ten to fourteen days to keep the bladder empty during the stage of healing. To ensure constant decompression of the bladder, the urethral catheter should be irrigated several times daily with 20 to 30 cc. of boric acid solution to prevent plugging with mucus and incrustation with urinary salts. Distention of the bladder may cause disruption of the wound, with subsequent recurrence of the fistula. If closure of the fistula has been difficult, or if the operation has been done partly or completely through the bladder, cystostomy drainage may be advisable.

Any evidence of *infection* should be treated promptly by careful irrigations and by sulfisoxazole or antibiotics.

Technique of Operation

General or spinal anesthesia is necessary.

A small fistula may be closed by fulguration of the tract and bladder drainage. Small, readily accessible fistulas may occasionally be cured by freshening the margins and simple closure with a purse-string of interrupted fine chromic catgut sutures The mucosa of the bladder should not be included in the sutures. Such operations can be successful *only if the bladder is kept completely decompressed during the* healing period.

The majority of fistulas have firm indurated margins which cannot be approximated without extensive layer dissection (Figs. 802, 803).

Adequate exposure is always essential. Traction sutures placed in the vaginal wall about the fistulous opening will aid in drawing the fistula downward. An episiotomy or a Schuchardt pararectal incision will greatly increase exposure.



FIGURE 802 Repair of a large, inaccessible vesicovaginal fistula. A Schuchardt pararectal incision has been made to increase exposure. The incision may extend a depth of 4 to 5 cm (Curtis: Textbook of Gynecology)

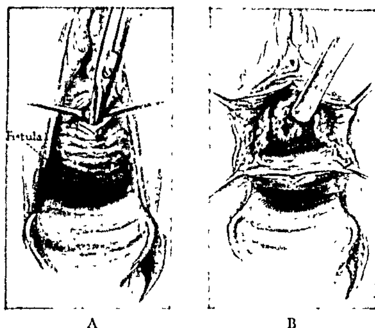


FIGURE 803. Repair of a large, inaccessible vesicovaginal fistula (*continued*). *A*, The vaginal wall is dissected from the bladder in a manner similar to that used in the operation for cystocele. *B*, The vaginal wall and fascial layers have been separated about the fistula The fistula opening is freshened, and the wound is closed in 3 layers when possible. (Curtis. Textbook of Gynecology.)

The vaginal wall, subvesical fascia and bladder wall are separated in layers a sufficient distance from the fistulous opening for careful suturing. Protruding mucosa from the bladder should be cut away. The closure should be made in layers. The opening in the bladder is closed first with fine chromic catgut sutures which do not penetrate the mucosa. The other two layers should be closed at a right angle to each other when possible. Interrupted sutures of no. 0 chromic catgut are used.

After closure the suture line may be carefully tested for leakage by gently distending the bladder with boric acid solution through a retention catheter. A retention catheter of the Foley type should be kept in place during the operation and used for the next ten to fourteen days for drainage.

If an episiotomy or a Schuchardt incision has been used, closure should be made in layers with chromic catgut.

OPERATIONS UPON THE CERVIX

CAUTERIZATION OF THE CERVIX

Indications

The surgical treatment of chronic infection of the cervix may be cauterization, trachelorrhaphy or amputation. Cauterization is one of the most common operations of gynecology and is indicated in a majority of cases of chronic infection and erosion. Trachelorrhaphy has a limited application in the repair of a deeply lacerated cervix, and amputation is the operation of choice in many of the chronically infected and hypertrophied cervices.

Many of the milder cases of cervical infection may be treated in the office with a nasal cautery without anesthesia. Deep cauterization or cauterization extending into the cervical canal usually requires an anesthetic.

Dangers and Safeguards

The cautery should not be used for acute cervicitis or during the acute stages of salpingitis.

Serious *infection* may follow cauterization of the cervix when the uterus is in retrodisplacement, unless suspension of the uterus is done at the same time.

Repeated cauterization of the external cervix is relatively harmless. *Pelvic cellulitis* may develop as a result of too frequent cauterizations of the cervical canal. *Cervical stricture* may develop after deep cauterization of the cervical canal and result in painful menstruation or difficult childbirth. This complication may be prevented by frequent postoperative examinations and, when necessary, dilatation of the cervical canal.

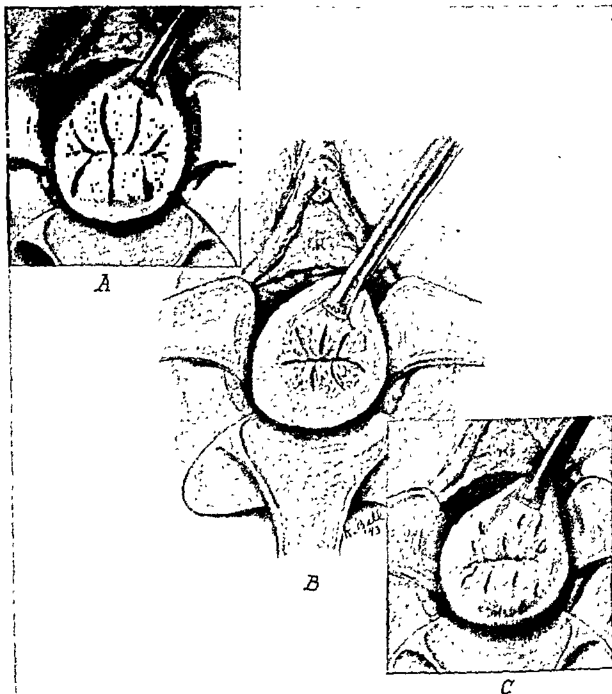


FIGURE 804. Cauterization of the cervix. *A*, Lines of deep cauterization. *B*, Superficial cauterization for surface infection *C*, Cautery puncture of nabothian follicle cysts

Bleeding from the cervix may occur within two weeks following operation when the burned tissue sloughs. The patient should be warned of this possibility. There will be a definite increase in the quantity of vaginal discharge for about two weeks following operation. During this time douches are not advised. Potassium permanganate douches given later will aid in the control of the disagreeable odor. Sexual relations should be avoided until healing is complete.

Technique of Operation (Fig. 804)

The upper margin of the cervix is grasped with a tenaculum and drawn toward the vaginal outlet as far as possible. Metal retractors are advisable to give good exposure and prevent accidental burning of the vaginal wall.

Cauterization is usually made along lines radiating outward from the cervical canal. When the infection is superficial, light cauterization is all that is necessary. Deep infection, involving the nabothian glands, requires deeper cauterization.

The cautery, heated to a cherry red, is drawn slowly outward from the cervical canal across the involved area. The burned strips should be placed from 0.5 to 1 cm. apart, depending upon the extent of the infection or erosion. When the infection is chiefly confined to the nabothian glands, simple puncture of these glands with the cautery may be sufficient.

EXCISION OF CERVICAL POLYP

General Considerations

Cervical polyps are usually benign, but may rarely show malignant changes. Because of the possibility of malignancy, all cervical polyps should be removed and examined microscopically. Since cervical polyps are almost always associated with chronic infection of the cervix, the latter should be treated when the polyp is removed.

Technique of Operation

A cervical polyp may be removed with knife or scissors. It should not be completely destroyed with a cautery because of the advisability of microscopic examination to exclude malignancy. Curettage is advisable for endometrial diagnosis and to remove any polypoid tissue in the cervical canal. The operation is completed by cauterization of the base of the polyp and the infected cervix.

TRACHELORRHAPHY

Indications

Slight lacerations of the cervix do not need repair. Primary suture of a deep laceration following childbirth may be done when there is not too much edema and distortion of the tissues. There is some danger that such an operation might cause stenosis of the cervical canal and interfere with uterine drainage. Unless bleeding is an important factor, it is usually better judgment to repair a cervix after healing is complete.

Infections of the cervix associated with old lacerations are usually treated by cauterization. When there is extensive hypertrophy and scarring, amputation is the

treatment of choice. A cervix deeply lacerated and relatively free from infection should be repaired by trachelorrhaphy. This operation is especially indicated in women past the childbearing age. It is generally believed that repair of cervical lacerations reduces the incidence of cancer.

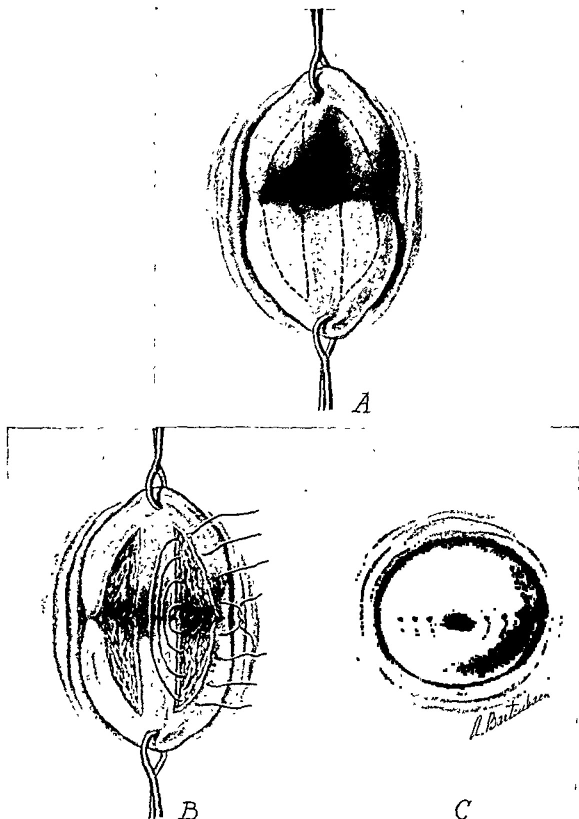


FIGURE 805. Technique of trachelorrhaphy. *A*, Lines of incision outlining areas to be denuded. *B*, Denuded areas shown with a strip of mucosa preserved to form the cervical canal. Sutures placed ready for tying. *C*, Completed operation

Technique of Operation (Fig. 805)

The cervix is drawn down to the vaginal opening with tenacula placed in the anterior and posterior lips. An area on each lip corresponding to the old torn surface is excised. The denudation must be carried deeply beyond the angle of the laceration. A strip of mucosa about 8 mm. wide is left in the midline of each lip to restore the old cervical canal.

The denuded surfaces are carefully approximated by no. 000 medium chromic catgut passed through the entire cervical wall down to, but not through, the cervical canal mucosa. When tied, these sutures close the old lacerations and reconstruct the cervical canal.

AMPUTATION OF THE CERVIX

Indications

Amputation of the cervix is indicated when hypertrophy, scarring and rigidity result from old lacerations and chronic infection. It also cures the troublesome leukor-

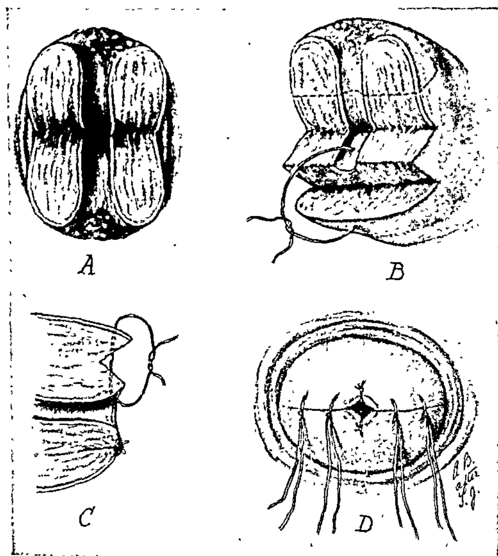


FIGURE 806. Curtis' "cervical bisection-wedge excision" operation *A*, Cervix is bisected to the depth of existing pathology *B*, Deep wedge excised from posterior lip. *C*, Section showing deeply placed chromic catgut sutures. *D*, Catgut sutures tied. Through-and-through silkworm-gut sutures unite the raw surfaces. Silkworm-gut sutures are left long and are removed in 2½ weeks. (Redrawn from Curtis· Textbook of Gynecology)

rheal discharge of chronic cervicitis. The danger of cancer is probably reduced by the removal of a scarred and infected cervix.

An amputation may be done by excision of the anterior and posterior lips of the cervix as practiced by Curtis or by the conical excision as described by Sturmdorf. Pregnancy following high cervical amputation may result in abortion.

Technique of Operation (Curtis) (Fig. 806)

The technique of Curtis is described as the "cervical bisection-wedge excision" operation. The cervix is bisected transversely to a depth beyond the area involved in infection. The diseased portion of each lip is then removed by the excision of a wedge-shaped section. The mucosa of the upper and lower lips is sutured to the mucosa of the cervical canal with no. 00 chromic catgut. Through-and-through deep sutures approximate the anterior and posterior lips. Silkworm gut may be used for the deep sutures. Such sutures are removed at the end of two and one-half weeks.

Technique of Operation (Sturmdorf) (Fig. 807)

A circular incision is made through the cervical mucosa beyond the area of infection to be removed. The mucosa is separated around the incision for a sufficient distance (0.5 to 1 cm.) to permit subsequent closure. As traction is applied with a vol-

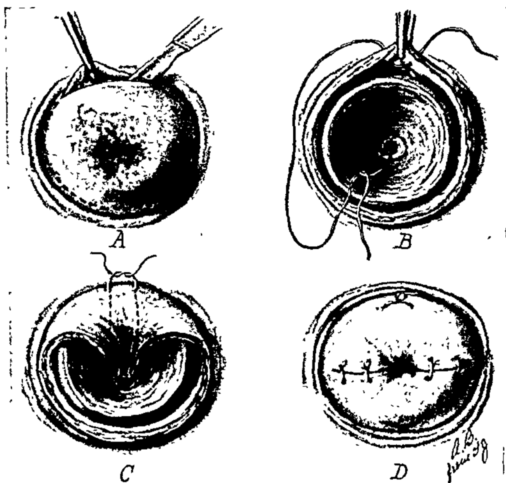


FIGURE 807 Sturmdorf's conical excision of the cervix. *A*, Line of incision for the formation of a circular mucosal flap *B*, Cervix has been cored out *C*, Mattress suture placed through wall of cervix to approximate mucosal flap and cervical canal. *D*, Final closure, showing the inverting mattress sutures

sellum, the diseased portion of the cervix is coned out with a sharp knife. Bleeding is controlled by hemostat pressure or suture ligatures.

A deep suture is passed through the anterior cervical wall, out through the cervical canal, through the margin of the denuded cervical mucosa in the midline, and out through the cervical canal and anterior wall to make a mattress suture. When this suture is tied, the denuded cervical mucosa is turned into the margin of the cervical canal. The posterior mucosal flap is sutured in a similar manner. Silkworm gut or no. 00 medium chromic catgut may be used. After the two primary sutures have been tied the remainder of the wound in the cervical mucosa is closed transversely with interrupted sutures. If silkworm gut sutures are used, they should be removed at the end of two weeks.

OPERATIONS UPON THE OVARIES

EXCISION OF OVARIAN CYSTS AND TUMORS

General Considerations

Small cysts of the ovary rarely require any treatment. Any cyst large enough to produce symptoms should be removed. Operation is always indicated when a malignant tumor of the ovary is suspected. An ovarian cyst with torsion of its pedicle will give rise to acute symptoms and make operation mandatory.

When a cyst does not completely destroy the ovary, resection and preservation of ovarian tissue is the operation of choice. This is particularly important in women of childbearing age.

Dermoids and malignant tumors of the ovaries should be removed when possible. Certain malignant tumors, even when associated with ascites or peritoneal implantations, may be improved by careful removal of the primary growth.

Dangers and Safeguards

Removal of a simple ovarian cyst is not a severe operation when the patient is in good general condition. Certain ovarian cysts of long standing may be associated with *extensive adhesions* and *distortion of anatomical structures* which may make operation hazardous. The three structures commonly involved with ovarian cysts and tumors are the bladder, ureter and intestine. To avoid serious complications, these structures must be identified and protected. Malignant tumors of the ovary may infiltrate these tissues or involve the iliac vessels to such an extent that complete removal is impossible.

Extensive dissection for the removal of ovarian cysts and tumors may be associated with serious *hemorrhage and shock*. When such is a possibility, blood should be available for transfusion before the operation is begun. Blood vessels of sufficient size to produce dangerous postoperative bleeding may be overlooked when the blood pressure is low in shock. A final check-up of all points within the operative field is advised before the abdomen is closed.

When infection of a cyst or tumor is a complicating factor, or when the intestine has been accidentally wounded, *peritonitis* may develop. In such cases drainage and the use of antibiotics are indicated.

Technique of Operation

A suprapubic midline or paramedian incision should be made of sufficient length to afford adequate exposure. The pelvic organs can be visualized best with the patient in the Trendelenburg position.

Resection of Simple Cyst (Fig. 808). An incision is made around the cyst at its junction with ovarian tissue. The cyst can usually be easily enucleated. If there are multiple cysts, the portion of the ovary involved may be excised. The wound in the ovary is closed with continuous or interrupted sutures of fine chromic catgut. Ovarian tissue is very friable, and sutures placed under tension will readily tear out.

Excision of Pedicled Cyst. This type of cyst is usually removed by delivery through the abdominal incision and ligation of the pedicle. When the cyst is large, preliminary aspiration with trocar and suction is indicated. Soiling of the peritoneum with cyst content should be avoided by closure of the trocar puncture wound with a heavy clamp when aspiration is completed.

The pedicle is doubly clamped and severed between the clamps. When the pedicle is large, it should be ligated in sections. In any event it is wise to transfix and ligate the pedicle to prevent the possibility of a slip of the ligature. Frequently the tube forms a part of the pedicle. It may be ligated as part of the pedicle or excised. After ligation the stump is carefully covered with peritoneum.

Excision of Parovarian Cyst. This type of cyst extends into the broad ligament.

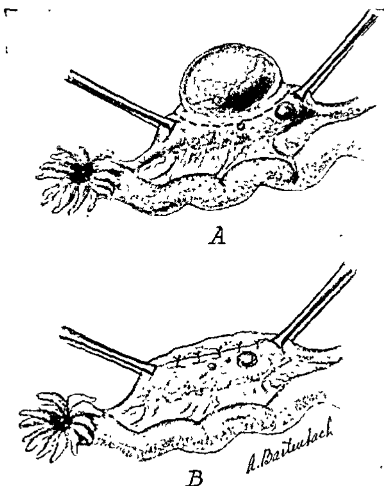


FIGURE 808. Excision of ovarian cyst. *A*, Line of incision at margin of cyst *B*, Closure of wound in ovary.

The vessels on the surface of the cyst are first securely clamped. The cyst is then shelled out of the broad ligament by blunt dissection. All vessels are clamped as the dissection proceeds. Deep in the broad ligament there is usually found an abundant blood supply which may form a vascular pedicle. This pedicle should be clamped before the cyst is removed. Bleeding deep in the broad ligament is difficult to control.

After the ligation of all vessels the defect in the broad ligament is obliterated with multiple sutures.

The three chief dangers which may be encountered in the removal of a parovarian cyst are hemorrhage and injury to the ureter or bladder. Careful identification of all structures and operation under direct vision will avoid these dangers.

Excision of Malignant Tumors. The operability of malignant tumors of the ovary must first be determined. When the bladder, ureter and intestines are extensively involved, the operation should be abandoned. When possible, the primary tumor should be removed. Removal of the primary growth, in certain types of tumors, may effect a cure or prolong life. Hysterectomy may be advisable in some cases.

The steps in the operation vary in each individual case. Blunt and sharp dissection is used. When possible, lines of cleavage are followed. Careful visualization of all structures is necessary to avoid injury to the intestine, ureter and bladder.

Drainage following operation is usually not necessary unless infection is present or suspected.

OPERATIONS UPON THE FALLOPIAN TUBES AND BROAD LIGAMENTS

SALPINGECTOMY

Indications

Salpingectomy is indicated for chronic salpingitis when there is a history of recurrent attacks of acute tubal infection, when the disease causes chronic invalidism, when there is a complicating pelvic abscess, and when there is an associated disease involving the uterus or ovaries which requires surgical intervention.

Acute salpingitis should not be treated by operation. A high percentage of patients with such acute infections make a symptomatic recovery with nonoperative treatment. A small percentage of patients recover completely and later bear children.

The ovaries should not be removed with the tubes unless they are hopelessly diseased. This is a good rule to follow regardless of the age of the patient. Hysterectomy and salpingectomy should be made a combined operation when such conditions as chronic metritis, uterine tumors which cannot safely be excised, chronic endometrial disease, and adherent misplacements of the uterus which cannot be treated properly by a corrective operation are associated with chronic salpingitis.

Technique of Operation (Fig. 809)

A paramedian incision is made, extending upward from the pubes to the level of the umbilicus. Exposure of the pelvic organs is improved by using the Trendelenburg position. The intestines are packed away from the operative field with moist gauze packs.

The uterus is first identified and, when possible, grasped with a tenaculum forceps. With the uterus as a guide, blunt dissection is begun to free the tubes and ovaries, which are usually adherent deep in the pelvis. In old chronic cases sharp dissection may be necessary to divide dense adhesions. Lines of cleavage can usually be found, which, when followed carefully, will prevent injury to the intestine, ureters and iliac vessels.

The broad ligament is clamped and cut close to the tube to avoid injury to the blood supply of the ovary. A wedge-shaped section of the uterine cornu is removed *with the tube. The wound in the cornu is closed with interrupted sutures, and the* broad ligament is ligated with multiple transfixing ligatures.

To eliminate raw surfaces, the peritoneum of the broad ligament may be used as a covering.

Since it is frequently desirable to suspend the uterus, a modified Coffey operation may be done as recommended by Wharton. The broad ligaments and round ligaments are sutured to the posterior surface of the fundus of the uterus to shorten these liga-

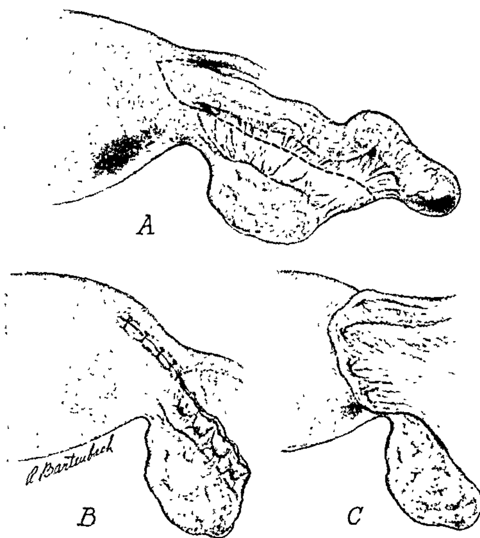


FIGURE 809 Technique of salpingectomy *A*, Line of incision for removal of tube. A wedge of the uterine cornu is removed with the tube. *B*, Wound in uterus and broad ligament sutured. *C*, Suture line covered with a fold of the broad ligament

ments and cover all raw surfaces. Fine chromic catgut is usually the suture material of choice.

Pelvic drainage is not advisable unless there is evidence of gross infection. When a drain is necessary, it should emerge at the lower end of the incision.

STERILIZATION OPERATION

Technique of Operation (Fig. 810)

An ellipitical incision is made about the uterine end of the fallopian tube, and the end of the tube is completely excised down to uterine mucosa. About 2 cm. of the tube are cut away, and the remaining cut end is ligated. The wound in the uterus is closed with interrupted sutures, and the ligated end of the tube is covered with peritoneum from the broad ligament.

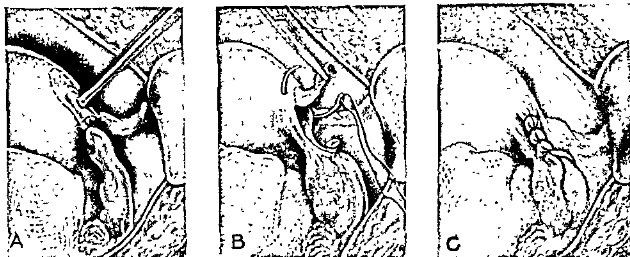


FIGURE 810 Technique of sterilization by resection of cornua. *A*, Line of incision about cornua and site of section of tube *B*, Resection of cornua and proximal end of tube. *C*, Closure of wound. Severed end of tube covered with peritoneum of broad ligament. (Redrawn from TeLinde: Operative Gynecology, J. B. Lippincott Company)

EXCISION OF ECTOPIC PREGNANCY

General Considerations

Ectopic pregnancy is most common in the fallopian tube, although it may occur in the ovary or abdominal cavity.

Immediate operation is indicated in almost all cases of tubal pregnancy, whether ruptured or unruptured, as soon as the diagnosis is made. In rare cases seen late, after the acute symptoms have subsided, recovery may be expected without operation.

Many patients with rapid hemorrhage into the abdominal cavity present urgent emergencies, and, unless prompt treatment is instituted, death will be the result. Blood or plasma should be given for shock while the patient is being prepared for operation, and these transfusions should be continued during the operation.

As a rule, appendectomy or other operative procedures are not advisable when operation is done for ectopic pregnancy.

Technique of Operation

A tubal pregnancy is usually easily lifted from the pelvis. Blood should be removed from the peritoneal cavity by suction. Bleeding may be temporarily controlled by manual compression of the broad ligament until the abdominal blood is removed and the intestines are packed out of the operative field.

The mesosalpinx is clamped, and the affected tube is cut away. The ovary can usually be preserved. Transfixing sutures are used to control bleeding from the broad ligament. Unless the patient is in desperate condition, time may be taken to cover raw surfaces with broad ligament peritoneum.

The abdominal wound is closed without drainage.

EXCISION OF BROAD LIGAMENT VARICOCELE

Technique of Operation

A varicocele is not infrequently associated with disease of the uterus and adnexa. In rare cases, varicosities may be the only evidence found to account for troublesome symptoms. Excision of varicose veins of the broad ligament may be made a part of any operation upon the uterine adnexa.

The peritoneal covering of the broad ligament is carefully dissected away from the veins to avoid bleeding into the tissues. The veins are then isolated, ligated and dissected out. Branches of the tortuous veins are clamped and ligated. The wound in the broad ligament is closed with fine catgut.

OPERATIONS UPON THE UTERUS

CURETTAGE

Indications

Curettage is most commonly indicated as a diagnostic measure or to remove retained membranes after abortion. It may be of value in the treatment of endometrial polyps and in selected cases of functional bleeding.

Dangers and Safeguards

Too vigorous dilatation of the cervix preliminary to curettage may result in a tear into the parametrium. Such an accident may be prevented by gentle, gradual pressure and by using the safety stop with which most cervical dilators are equipped.

The uterine wall is rather easily perforated with a curet. Rough usage of all intrauterine instruments should be carefully avoided. Perforation of the uterine wall might cause a fatal peritonitis. Curettage is contraindicated in acute infections involving the uterus or fallopian tubes.

Crossen warns that excessive traction on the cervix during curettage may cause overstretching of the uterosacral ligaments and broad ligaments, resulting in permanent relaxation and loss of their supportive power.

Technique of Operation

The cervix is held in a tenaculum during the operation of curettage. Preliminary dilatation of the cervical canal with a dressing forceps will usually permit the introduction of a uterine dilator. The entire cervix is gently stretched in all directions to prevent tearing. Dilatation is continued until the cervix will admit a medium-sized curet.

Before the curet is introduced, the length of the uterine cavity is measured by the careful introduction of a uterine sound. The curet then follows, and all surfaces of the interior of the uterus are carefully scraped until a sensation of grating is produced by the firm internal wall.

The debris removed from the uterus is collected on gauze sponges for gross and microscopic examination.

Packing of the uterus is not necessary unless bleeding is excessive. In such an event the packing is to be removed in twenty-four hours. The patient may leave the bed in two or three days unless there is some complicating condition requiring longer bed rest.

OPERATIONS FOR RETRODISPLACEMENT OF THE UTERUS

General Considerations

Simple retrodisplacement of the uterus which does not cause symptoms is rarely an indication for operation. A retrodisplacement causing sterility, abortion, dysmenorrhea or backache is frequently benefited or cured by operation. Retroversion or retroflexion may be associated with pelvic infections, tumors, or injuries resulting from childbirth. Such malpositions should be corrected as part of the surgical treatment of

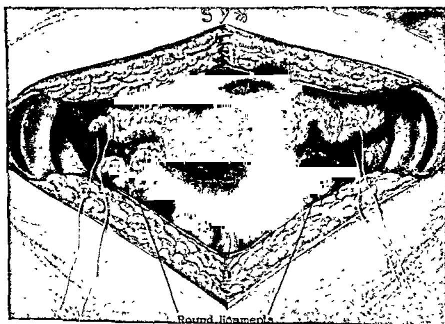


FIGURE 811 Modified Gilliam suspension of the uterus. A guide ligature is passed around each round ligament 4 to 5 cm from the uterine cornu. These ligatures are used to draw the round ligaments through the inguinal rings. (Wharton Gynecology.)

pelvic disease. However, if the uterus is much diseased, it is usually preferable to do a hysterectomy rather than a suspension.

The two operations most frequently used to suspend the uterus are the modified Gilliam and the Baldy-Webster. These operations do not interfere with the normal progress of pregnancy.

Technique of the Modified Gilliam Suspension of the Uterus (Figs. 811 to 814)

For good exposure of the pelvic organs, the patient should be placed in the Trendelenburg position.

An incision is made in the midline above the pubes. When the pelvis has been explored and the uterus lifted into normal position, a guide ligature is placed beneath each round ligament about 5 cm. from the uterus. The fascia is separated from the anterior surface of each rectus muscle about 3 cm. from the pubic bone to make a passage for the round ligament. A long, curved hemostat is passed beneath the fascia, and external to the peritoneum to the internal ring. Tension on the round ligament aids in the identification of this point, which must be located under direct vision. An incision is made through the peritoneum over the tip of the hemostat, which is then passed through the peritoneal opening to grasp the guide ligature. With the guide ligature the round ligament is withdrawn extraperitoneally and between the rectus muscle and fascia. The same procedure is followed on the opposite side.

After withdrawal of the round ligaments they are tested for tension before any sutures are placed. The round ligaments must be short enough to support the uterus and lax enough to avoid pain due to excess tension. These ligaments are then sutured to the fascia with silk or cotton.

Before closing the abdomen the point of exit of the round ligament through the peritoneum must be carefully examined. An opening between the ligament and abdominal wall must not be left through which a loop of intestine could pass to produce intestinal obstruction.

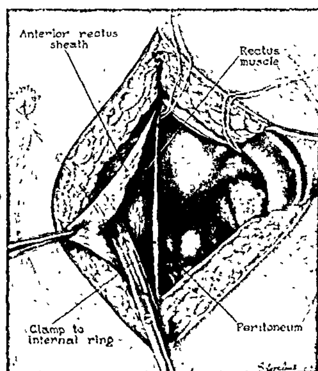


FIGURE 812. Modified Gilliam suspension of the uterus (*continued*) The rectus fascia is separated from the muscle 3 to 4 cm above the pubic bone A curved hemostat is thrust beneath this fascia to grasp the guide ligature at the internal inguinal ring (Wharton: Gynecology)

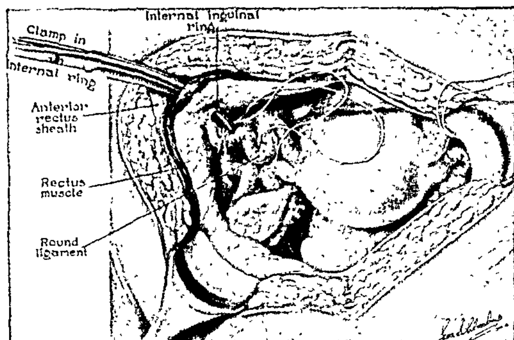


FIGURE 813. Modified Gilliam suspension of the uterus (*continued*). A curved hemostat is passed through an opening in the peritoneum at the internal inguinal ring. Through this opening the guide suture and round ligament are drawn beneath the rectus fascia. (Wharton: Gynecology.)

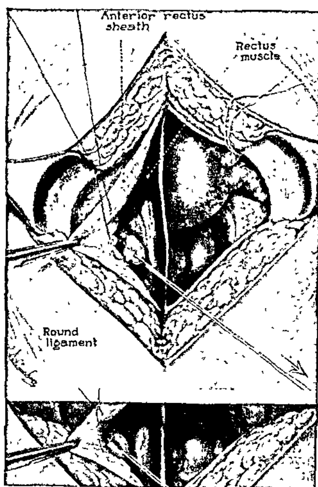


FIGURE 814. Modified Gilliam suspension of the uterus (*concluded*) The round ligament is drawn beneath the rectus fascia and tested for proper tension It is then anchored to the fascia with interrupted sutures of silk. (Wharton Gynecology.)

The abdomen is closed in layers. If the round ligaments are long enough, they may be united in the midline beneath the fascia.

Technique of the Modified Baldy-Webster Suspension of the Uterus (Fig. 815)

The abdomen is opened through a suprapubic midline or paramedian incision. Good exposure of the pelvic organs is obtained by placing the patient in the Trendelenburg position and packing the intestines well out of the operative field.

The uterus is drawn upward and forward with a tenaculum. This maneuver places the uterosacral ligaments on tension and aids in their identification. The uterosacral ligaments are united in the midline with three to five interrupted silk sutures.

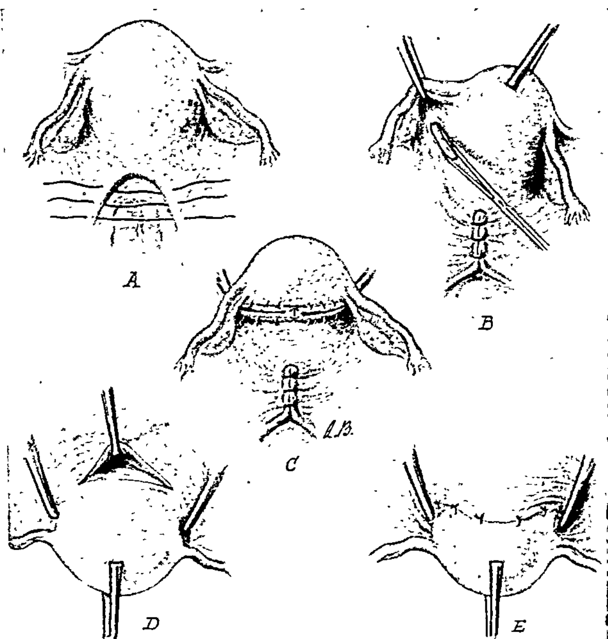


FIGURE 815 Technique of the Baldy-Webster operation *A*, Sutures placed in the uterosacral ligaments. *B*, The uterosacral ligaments united with interrupted silk sutures. Round ligament drawn through the broad ligament below the ovarian ligament. *C*, Round ligaments sutured behind the fundus uteri *D*, Vesicouterine fold is separated from the uterus by sharp and blunt dissection. *E*, Vesicouterine fold sutured to anterior wall of fundus (*Redrawn from Curtis*)

If there is much relaxation of the tissues, the posterior leaves of the broad ligaments may also be united with sutures.

As the next step the broad ligament is punctured with a curved hemostat below the utero-ovarian ligament on each side. Relatively avascular areas are selected to avoid bleeding. The round ligaments are drawn through the openings made by the hemostat and sutured together behind the uterine fundus. These ligaments are then sutured to the posterior surface of the fundus with interrupted silk sutures. The line of attachment of the ligaments to the uterus should be below the level of the insertion of the utero-ovarian ligaments, usually 2 to 4 cm. from the top of the fundus.

The final step in the suspension is the advancement of the uterovesical reflection of the peritoneum upward upon the anterior surface of the fundus. With blunt dissection the peritoneum is separated from the uterus a distance of about 5 cm. It is then displaced upward on the fundus to a point just below the level of the insertions of the round ligaments. Here the peritoneum is securely attached to the uterus with interrupted silk sutures.

The abdominal wound is closed without drainage.

OPERATIONS FOR UTERINE PROLAPSE

General Considerations

The interposition operation of Watkins-Wertheim for uterine prolapse produces satisfactory results in a high percentage of cases. It is probably the simplest of several types of operations which have been described for the cure of prolapse or procidentia. In general, this operation should not be done during the childbearing period. The small atrophic uterus of the elderly patient is most suitable for the interposition operation. A large uterus, a uterus containing fibroids, and an unexplained bleeding from the uterus are all contraindications to this operation.

It is the opinion of TeLinde that the Manchester (Donald or Fothergill) operation is a satisfactory procedure when (1) there is a cystocele associated with a first-degree prolapse; (2) when childbearing need not be considered; and (3) when there is not a marked retroversion of the uterus. In many cases of uncomplicated uterine prolapse a vaginal hysterectomy is the preferred procedure.

Dangers and Safeguards

The chief dangers of these operations are *injury to the bladder or urethra* and *injury to the intestine*. These complications can be avoided by good exposure of the operative field and careful identification of each anatomical structure. If necessary, a sound may be passed into the bladder as a guide in the dissection.

Peritonitis and other *postoperative infection* can be avoided by thorough preoperative preparation of the vagina and vulva.

Shock is usually not an important problem. Vaginal pelvic operations are usually less shocking than abdominal pelvic operations.

Postoperative bladder pain and *retention of urine* are common. These may be treated by retention catheter or regulated catheterization. Daily washing of the bladder with boric acid solution is usually necessary. Sulfisoxazole or appropriate antibiotics are indicated for the treatment of cystitis.

Technique of the Interposition Operation (Fig. 816)

A transverse incision is made at the junction of the vaginal wall with the anterior wall of the cervix. From this incision the vaginal wall is separated from the bladder in the midline by blunt dissection. The musculofascial plane is usually easily found and followed. The vaginal wall is then incised in the midline up to the urethral meatus.

Flaps of vaginal wall and musculofascial tissue are dissected from the bladder wall to the lateral walls of the vagina. The vaginal wall and musculofascial layer are separated to form a musculofascial flap for future closure.

Separation of the bladder from the cervix is the next important step. This dissection must be made close to the cervical wall to prevent bladder injury. Sharp dissection will be necessary to divide the musculofascia at the lateral attachments of the cervix.

To expose the peritoneum for incision, the cervix is drawn downward and the bladder is lifted upward with a retractor. At the point of reflection on the uterus the peritoneum is divided transversely. The opening in the peritoneum permits pelvic

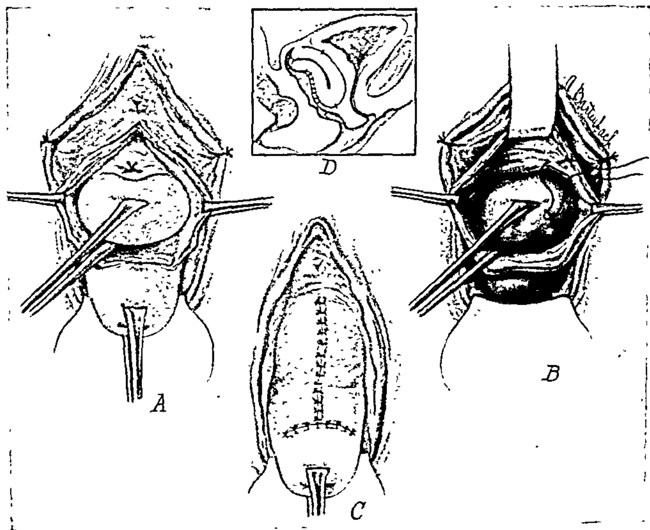


FIGURE 816 Technique of the interposition operation *A*, The peritoneum has been incised and the fundus uteri delivered The peritoneum is sutured to the posterior surface of the uterus. *B*, The uterus is fixed in position by suturing the fundus to the fascia beneath the pubic arch *C*, The vaginal mucosa closed *D*, Position of uterus between bladder and vaginal wall.

exploration and delivery of the uterine fundus. To close the peritoneum, its margin is sutured to the posterior wall of the fundus.

The musculofascial layer already prepared is sutured to and over the anterior wall of the uterus. This fixes the uterus directly beneath the bladder and urethra. Excess vaginal wall is cut away, and the vaginal wound is closed with interrupted sutures which include the underlying musculofascia.

A perineal repair is made as a final step in the operation.

Technique of the Manchester Operation for Uterine Prolapse (Figs. 817 to 823)

The Manchester operation has also been called the Donald-Fothergill and parametrial fixation operation. Wharton states that this operation yields excellent results in first- and second-degree prolapse, but is doubtful of its value in the treatment of complete procidentia.

The operation is done with the patient in the lithotomy position. TeLinde recommends dilatation and curettage to exclude any evidence of malignancy and to enlarge the cervical canal for convenience of suture of the posterior mucosal flap.

The cervix is drawn outward with a tenaculum, and an incision is made from the cervix to the urethral meatus. This incision is connected with a transverse incision at the cervix. The vaginal mucosa is dissected up on each side as in the cystocele operation. This dissection is extended upward above the cervical neck to the vesicouterine reflection of the peritoneum. The lateral cervical ligaments (broad ligament attachments) are isolated, ligated and divided near the cervix. The cervical branches of the uterine arteries are also ligated and divided.

The cervix is amputated in line with the transverse cervical mucosa incision.

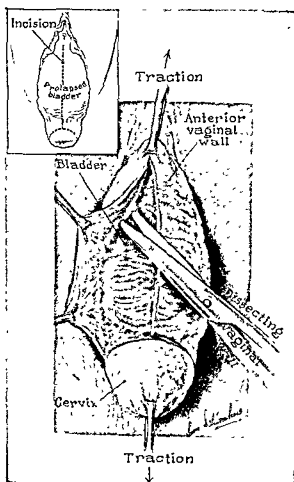


FIGURE 817. Technique of the Manchester operation Incisions in the vaginal wall and dissection of vaginal wall mucosa flaps as in cystocele repair (Wharton· Gynecology)

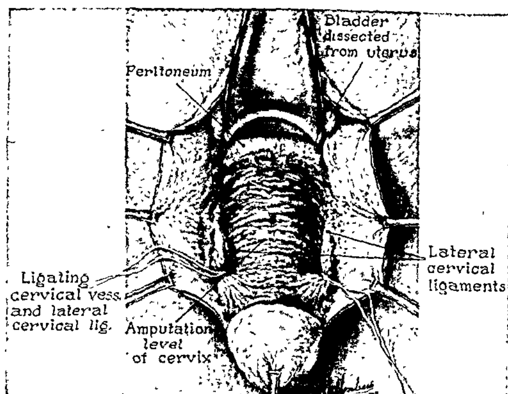


FIGURE 818. Technique of the Manchester operation (*continued*) Dissection has been extended to separate the bladder from the uterus and vaginal wall. Lateral dissection of the vaginal wall flaps has exposed the lateral cervical ligaments. The lateral cervical ligaments are ligated. At this stage the descending branches of the uterine arteries are ligated and cut (Wharton: Gynecology.)

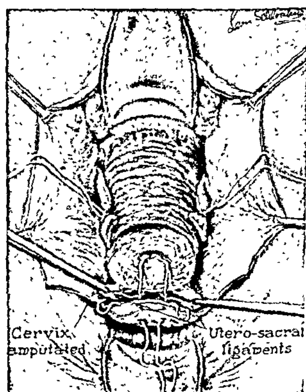


FIGURE 819. Technique of the Manchester operation (*continued*). The lateral cervical ligaments have been divided, and a high amputation of the cervix has been made. The

The mucosa is then separated from the cervical stump until it can be easily mobilized and sutured to the posterior margin of the cervical canal. This mucosal dissection exposes the uterosacral ligaments, which may be shortened and reimplanted into the cervical stump. Shortening of the uterosacral ligaments lifts the cervix high in the pelvis. The posterior cervical flap of mucosa is sutured to the posterior wall of the cervical canal with a Sturmdorf suture.

The previously ligated lateral cervical ligaments (broad ligament bases) are overlapped and sutured to the anterior wall of the cervix as high as possible. The fascia beneath the bladder on each side is separated from the vaginal mucosa flaps and sutured together over the lateral cervical ligaments.

The excess of vaginal mucosa on each side is cut away, and the mucosa is united in the midline. A Sturmdorf suture may be used to close the mucosa over the cervix and fix the mucosa to the anterior cervical canal.



FIGURE 820 Technique of Manchester operation (*continued*) The lateral cervical ligaments are overlapped and sutured to the anterior wall of the uterus. (Wharton: Gynecology.)



FIGURE 821. Technique of the Manchester operation (*continued*). The subvesical fascia is approximated with mattress sutures. This illustration does not show the fascia dissected from the vaginal mucosa. (Wharton: Gynecology.)

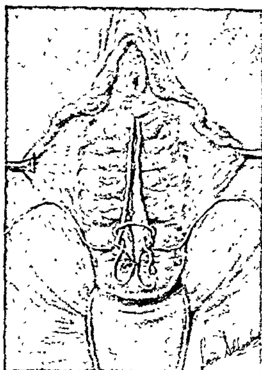


FIGURE 822. Technique of Manchester operation (*continued*). The excess vaginal mucosa has been cut away, and a Sturmdorf suture has been placed to close the mucosa over the cervix. (Wharton. Gynecology.)

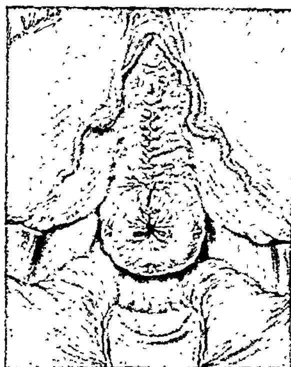


FIGURE 823. Technique of the Manchester operation (*concluded*). The operation completed. The vaginal wall has been closed with a continuous suture of fine chromic catgut. (Wharton. Gynecology.)

Number 0 chromic catgut may be used for all deep sutures. Number 000 chromic catgut is suitable for the mucosal sutures.

A perineal repair is made to complete the operation.

MYOMECTOMY

Indications

Abdominal myomectomy is the operation of choice for removable myomas of the body of the uterus in young women to preserve the childbearing function. If the

uterus contains too many tumors, it may be impossible to excise them all and preserve the anatomical structure of the organ. In selected cases small myomas may be left in the body of the uterus with the expectation that a successful pregnancy will follow. However, such tumors may later grow and become an indication for hysterectomy.

If a woman is past the childbearing age or if associated pelvic disease makes childbearing impossible, myomectomy is usually contraindicated.

Vaginal myomectomy is indicated for submucous myomas which protrude into the vagina. This operation is much less severe than abdominal myomectomy and may be successfully used if the myoma is pedunculated and not attached above the cervical canal.

Technique of Abdominal Myomectomy

Small myomas may be enucleated through a small incision made directly over the tumor. Larger myomas should be excised by making an elliptical incision around the tumor or tumor pedicle. A line of cleavage can usually be found which permits easy enucleation with little bleeding. If bleeding is encountered, the vessels should be ligated. Closure of the wound in the uterus will usually require two rows of sutures. The wound should be peritonealized when possible.

Technique of Vaginal Myomectomy

A myoma protruding from the cervix should be grasped with forceps and gently drawn downward to obtain exposure. It is usually preferable to sever the pedicle of a myoma with a cautery. The pedicle may also be severed with a wire snare by passing a fulgurating current through the instrument. If there is any bleeding, the pedicle should be ligated at its base.

HYSTERECTOMY

Indications

The operations commonly used for removal of the uterus are supravaginal or subtotal hysterectomy, total or panhysterectomy, vaginal hysterectomy and radical panhysterectomy. (Wertheim). The last includes complete removal of the uterus with the tubes, ovaries and regional lymphatics.

The choice of operation must depend upon the judgment and skill of the surgeon. In general, total abdominal or vaginal hysterectomy is indicated in benign conditions and certain cases of uterine prolapse. Radical panhysterectomy is the operation of choice in malignant pelvic disease not appropriate for radiation therapy. Removal of the ovaries should be avoided, when possible, prior to the age of menopause.

Abdominal supravaginal hysterectomy is recommended only in the very poor risk patient or in the patient who tolerates her surgery or anesthesia poorly. It is poor surgical judgment to leave a potential site of carcinoma behind when it serves no useful purpose.

Dangers and Safeguards

The operative risk of any type of hysterectomy must depend upon the extent of the disease for which the operation is done, the type of operation, the general condition

and age of the patient, and, finally, the skill of the operator. In general, the mortality rate of hysterectomy should not exceed 1 to 3 per cent. A somewhat higher rate may be expected following total hysterectomy of the radical Wertheim type.

Injuries to the bladder or ureters may occur unless all structures are carefully identified and visualized. The danger of injury to these structures is much increased if there has been an earlier pelvic operation or if the parametrial tissues are infiltrated with infection, scar tissue or tumor tissue. An injury to the bladder may produce a vesicovaginal fistula which may not be evident for several days following the operation. Ureteral injury may likewise cause a ureterovaginal fistula. A severed ureter should be immediately repaired by anastomosis or implanted into the bladder. A permanent stricture of the ureter may develop from a crushing injury, a misplaced suture or an anastomosis. In the more difficult operations it may be advisable to safeguard the ureters by preoperative catheterization.

A careful *examination of the cervix* is imperative to exclude any evidence of cancer before a supravaginal hysterectomy is done. Carcinoma of the cervical stump has been studied by Henriksen, who found an incidence of 0.45 per cent in 6550 subtotal hysterectomies.

Hemorrhage and shock are always possible dangers of hysterectomy. Whole blood or plasma should be available for prompt administration when necessary. Postoperative bleeding is a serious complication and may be prevented by scrupulous care in placing ligatures or by the use of suture ligatures. Vessels may retract into the broad ligament and pass unnoticed until a large pelvic hematoma is discovered later.

Technique of Subtotal Abdominal Hysterectomy (Figs. 824 to 827)

This procedure should be used only when the condition of the patient or the pathologic state contraindicates total hysterectomy.

Satisfactory exposure of the operative field is obtained by placing the patient in the Trendelenburg position and by packing the intestines out of the pelvis with moist gauze.

The round ligaments are ligated and divided. As the uterus is lifted with a tenaculum, the bladder peritoneum is divided at its reflection on the uterus and dissected downward below the level of the internal os. This dissection is carried laterally into the broad ligaments to expose the uterine vessels. The tubes and the utero-ovarian ligaments are clamped and divided near the uterus. These structures may be ligated when cut, or held in clamps until the uterus is removed. The peritoneum covering the posterior surface of the cervix is incised and dissected away from the cervical wall for a short distance to form a flap.

Upon completion of the dissection the uterine vessels are carefully identified, clamped and severed. These vessels are securely ligated, preferably with suture ligatures. The uterus is amputated by coning out the cervix, leaving little of the cervical canal remaining. Closure of the cervical stump and control of minor bleeding vessels are easily accomplished with deep interrupted sutures.

The round ligaments, tubes and utero-ovarian ligaments are sutured to the stump of the uterus on each side. This step prevents prolapse of the cervix.

To cover all raw surfaces, the bladder peritoneum is sutured to the posterior wall of the cervix and to the surfaces of the round ligaments and tubes.

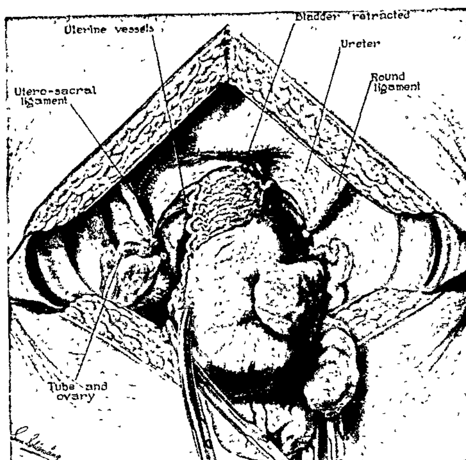


FIGURE 824. Subtotal abdominal hysterectomy. The utero-ovarian ligaments, round ligaments and tubes have been cut and tied The peritoneum and bladder have been separated from the cervix. These steps permit identification and visualization of the uterine vessels. The normal positions of the ureters are shown (Wharton: Gynecology.)

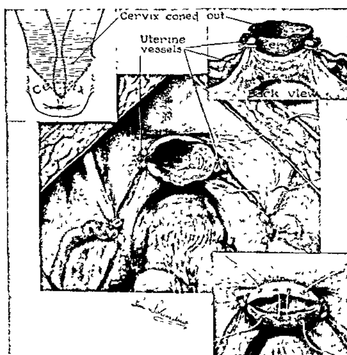


FIGURE 825. Subtotal abdominal hysterectomy (*continued*). The uterus is amputated by cutting a deep cone out of the cervix. This conical enucleation may remove all the cervical mucosa down to the charred area of the cervical cauterization The cervix is closed with interrupted sutures. (Wharton: Gynecology.)



FIGURE 826. Subtotal abdominal hysterectomy (*continued*). The round, utero-ovarian and utero-sacral ligaments are anchored to each side of the cervix with a transfixing suture. This prevents prolapse of the cervical stump. (Wharton: Gynecology.)

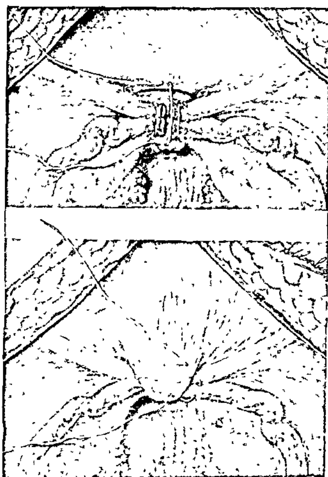


FIGURE 827. Subtotal abdominal hysterectomy (*concluded*). The upper figure shows the cervix firmly suspended The first peritonealizing suture is placed. The lower figure shows the operative field covered with bladder peritoneum The peritoneum is sutured behind the cervix Lateral sutures placed to cover all raw surfaces complete the closure of the operative field (Wharton. Gynecology.)



FIGURE 828. Abdominal panhysterectomy. The peritoneum has been incised along its reflection on the anterior wall of the uterus. On the right the round ligament, fallopian tube and utero-ovarian ligament have been divided and ligated. On the left these structures have been freed and are being supported by the index finger (Richardson: Surg., Gynec. & Obst., Vol. 48. By permission of Surgery, Gynecology and Obstetrics)



FIGURE 829. Abdominal panhysterectomy (*continued*). The uterine vessels have been clamped and tied. The bladder is being carefully freed from the cervix with blunt dissection in the relatively avascular central zone. By this dissection the bladder usually separates, leaving the pubocervical (subvesical) fascia covering the cervix Most of the venous plexus is contained in the subvesical fascia. (Richardson: Surg., Gynec & Obst, Vol. 48. By permission of Surgery, Gynecology and Obstetrics.)

The abdominal wound is closed without drainage except in those cases in which infection is encountered during the operation.

Technique of Abdominal Panhysterectomy (Figs. 828 to 833)

The preliminary dissection in this operation does not differ in essential details from that described above for subtotal hysterectomy.

The bladder is separated to a point below the level of the lower end of the cervix. This dissection is extended laterally to further separate the cervix from the bladder and ureters. At this stage it is wise to identify the ureters definitely to safeguard them from possible injury.

To mobilize the cervix posteriorly, the peritoneum is incised across the utero-sacral ligaments and dissected downward and laterally close to the cervical wall. The uterosacral ligaments are divided and ligated. As a final step in freeing the cervix, the broad ligaments are clamped, divided, and securely tied with transfixing sutures. These steps should completely free the cervix and expose the upper part of the vagina.

The vagina is cut across just below the tip of the cervix and held with Allis clamps. At each lateral margin of the vagina a suture is placed for fixation; to these points the ends of the tubes, round ligaments, utero-ovarian ligaments and uterosacral ligaments are strongly sutured. This step suspends the vagina. Interrupted sutures are



FIGURE 830. Abdominal panhysterectomy (*continued*). The uterus is lifted well forward, and an incision is made through the peritoneum 1 cm above the attachments of the uterosacral ligaments. With finger dissection the peritoneum is separated from the cervix and upper vagina to a level below the external os uteri. (Richardson Surg., Gynec. & Obst., Vol. 48 By permission of Surgery, Gynecology and Obstetrics.)



FIGURE 831. Abdominal panhysterectomy (*continued*). The peritoneal covering of the cervix has been removed anteriorly and posteriorly. The basal segment of the broad ligament, together with the vascular plexus, is shown clamped and divided. A suture ligature encircles the vessels. (Richardson: Surg., Gynec. & Obst, Vol. 48 By permission of *Surgery, Gynecology and Obstetrics*)

used to close the vaginal opening. Drainage through the vaginal opening is rarely advisable.

The raw areas are peritonealized by suturing the bladder peritoneum to the peritoneum covering the uterosacral ligaments.

Abdominal drainage is usually not necessary.

Technique of Vaginal Hysterectomy (Fig. 834)

The technique of this operation is not difficult, if its limitations are carefully observed. It should not be attempted for large uterine tumors or when there is fixation of the uterus by inflammatory disease in the uterine adnexa. Vaginal hysterectomy causes less shock than abdominal hysterectomy and is therefore particularly suitable for women in advanced years.

A circular incision is made around the cervix. By blunt and sharp dissection the vaginal wall is completely separated from the cervix. This dissection exposes the descending branches of the uterine arteries which lie on each side of the cervix in the bases of the broad ligaments. It is usually possible to identify the uterosacral ligaments, which are cut and ligated. The ligatures placed on the uterosacral ligaments are left

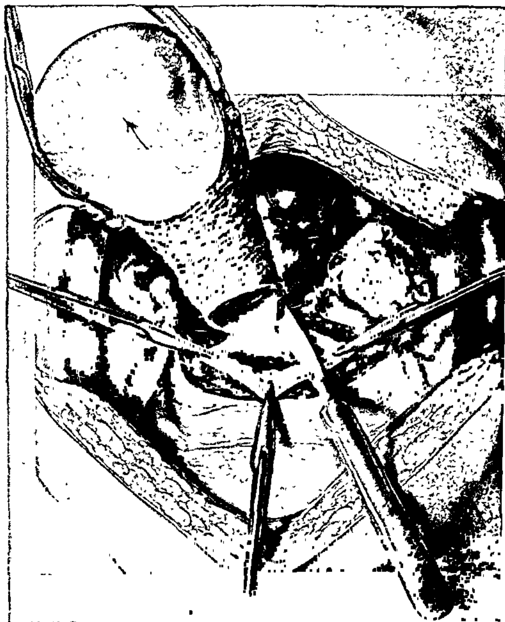


FIGURE 832. Abdominal panhysterectomy (*continued*). The uterus is amputated across the vaginal



FIGURE 833. Abdominal panhysterectomy (*concluded*). Closure of the vaginal vault with anchorage to it of the round ligaments, tubes and utero-ovarian ligaments. All raw surfaces are carefully peritonealized. Drainage through the vaginal vault is rarely necessary. (Richardson: Surg , Gynec. & Obst , Vol. 48 By permission of Surgery, Gynecology and Obstetrics)

long to aid in later identification of these structures. The posterior peritoneum close to the cervix is then opened. These steps free the uterus posteriorly.

The bladder is carefully mobilized, and the peritoneum is opened at its reflection upon the uterus. This step permits delivery of the fundus which exposes the utero-ovarian ligaments. Heavy clamps are carefully placed close to the uterus to include the round ligaments, tubes, utero-ovarian ligaments and broad ligaments. Careless clamping of these structures may injure the ureters, which lie 2 to 3 cm. lateral to the cervix on each side. These structures are then divided between the clamps and the uterus. This step completes the removal of the uterus.

The uterine arteries and broad ligaments held in the clamps are ligated with suture ligatures. These sutures must be placed securely to avoid bleeding. Mattress sutures are used to unite the broad ligaments in the midline. The peritoneum is closed with interrupted sutures.

In some cases it may be easier to deliver the fundus of the uterus through the cul-de-sac and clamp the broad ligaments from below upward. This technique is as easy of execution as the one described above.

When a cystocele is to be repaired, the vaginal dissection is done first as in the operation for cystocele.

After the broad ligaments have been united the upper margin of the broad ligaments, which includes the round and utero-ovarian ligaments, is sutured beneath the subpubic arch.

The excess of vaginal wall is cut away, and the vagina is closed with interrupted sutures. A perineal repair is done as part of this operation.

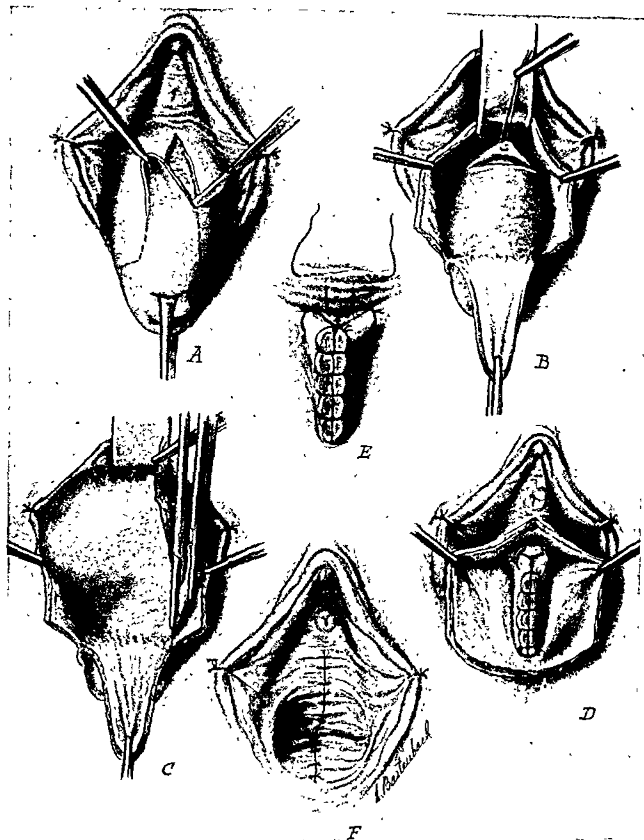


FIGURE 834. Technique of vaginal hysterectomy. *A*, Incisions in anterior vaginal wall A flap of mucosa is constructed *B*, Vaginal flaps have been dissected back and peritoneum has been incised. *C*, The fundus uteri delivered and the broad ligament structures clamped and cut. *D*, Broad ligaments sutured together. *E*, The upper parts of the broad ligaments are sutured to the fascia beneath the pubes *F*, Vaginal wall closed

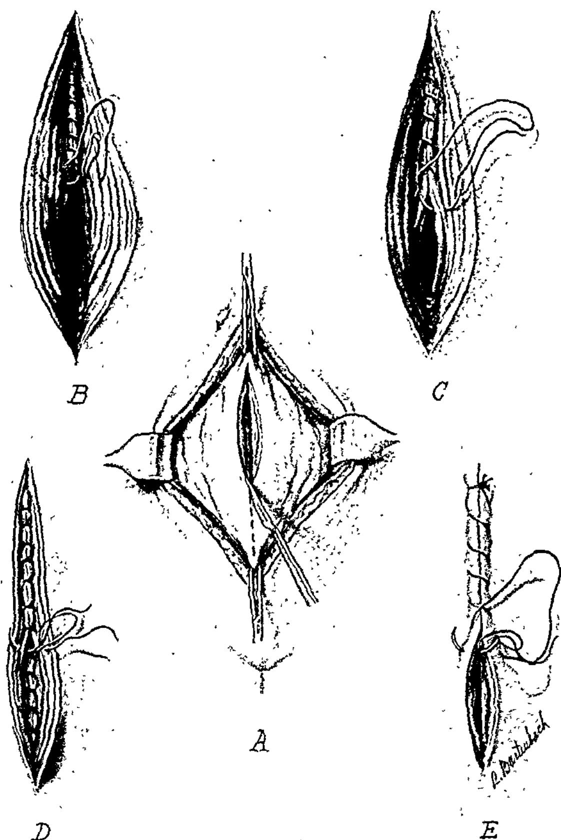


FIGURE 835. Technique of cesarean section *A*, Wall of uterus is held with Allis forceps while i cision is made *B*, First row of catgut sutures to close uterine wall. *C* and *D*, Second and third rows sutures in uterine muscle *E*, The fourth row of sutures closes both muscle and peritoneum.

CESAREAN SECTION

Technique of Operation (Fig. 835)

Ethylene or cyclopropane anesthesia may be used. DeLee recommends local anesthesia.

An incision is made in the midline extending from the pubes to the umbilicus. As the abdominal wall is thin in pregnancy, care must be taken not to wound intra-abdominal organs accidentally. The bladder is displaced upward and may be injured if not recognized.

The uterus is exposed in its midline and steadied with two volsella. A gauze pack is then tucked in beneath the margin of the wound to protect the abdominal cavity from spillage of amniotic fluid and blood. An incision about 12 cm. long is made in the wall of the uterus. It is safer to make a small opening through the uterine wall at one point in the incision and extend it upward and downward between protecting fingers on the inside of the uterus.

The baby is extracted by the feet and the cord is clamped in two places and divided. A cubic centimeter of pituitary extract may be given intramuscularly at this time. The baby is cared for by an assistant while the placenta is delivered. The placenta usually separates promptly, and the membranes are removed by gentle traction to prevent tearing. After removal of the secundines the uterine cavity is carefully sponged out with a warm moist gauze pack and inspected for any retained portions of placenta or membranes. A pack is placed in the uterus until a portion of the posterior row of sutures is placed. Gentle kneading and compression of the uterus will stimulate contraction.

The uterus is closed with four rows of no. 0 chromic catgut sutures, as shown in Figure 835. The first row of sutures should not penetrate the endometrium. Sufficient time should be taken to approximate the margins of the wound carefully to prevent bleeding and promote sound healing.

Amniotic fluid and blood are removed from the abdominal cavity by suction. The peritoneum is closed with catgut. The fascia may be imbricated to add strength to the closure.

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